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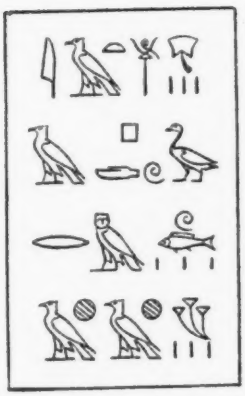

OCTOBER · 1948

Vol. 12 No. 4

CONTENTS

In Appreciation of Aldo Leopold ..... *Paul L. Errington* 341

Marsh-Blasting as a Wildlife Management Technique ..... *Maurice W. Provost* 350

Dyeing Birds for Identification ..... *L. A. Wadkins* 388

Ohio Studies with Repellent Materials with Notes on Damage to Corn by Pheasants and other Wildlife ..... *C. A. Dambach and D. L. Leedy* 392

The Use of Ovulated Follicles in Determining Eggs Laid by the Ring-Necked Pheasant ..... *Cyril Kabat, Irven O. Buss and Roland K. Meyer* 399

Winter Activities of Wild Turkey in West Virginia ... *Fred A. Glover* 416

The Management of Georgia Deer ..... *George W. Allen* 428

Briefer Articles:

A Method for Correcting Kill Estimates from Waterfowl Banded During the Hunting Season ..... *David H. Thompson and John Jedlicka* 433

Safflower as a Winter Game Bird Food ..... *K. E. Hungerford* 436

Incisor Width as an Age Criterion in Muskrats ..... *Allen Brohn and Charles E. Shanks* 437

Review 440

Constitution and By-Laws of the Wildlife Society 441

Index, Volume 12 445

Title Page and Contents ..... i–iv

Officers, Committees, and Members, The Wildlife Society, 1948 ... v–xxxi

The Journal of Wildlife Management is printed by The George Banta Publishing, Co., and published by The Wildlife Society in January, April, July, and October, at 450 Ahnaip St., Menasha, Wisconsin. Sent free to all members not in arrears for dues. Subscription $5.00 per year; current numbers $1.25. All back issues of the Journal are again available for purchase at $6 per volume, $1.50 per issue. Members whose dues lapsed due to wartime military service may procure back numbers issued during their period of service at their former membership rates.

Manuscripts for publication, books and papers for review, news notes and correspondence concerning them should be sent to the *Editor*, Harlow B. Mills, Illinois Natural History Survey, Urbana, Illinois.

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SUGGESTIONS ON MANUSCRIPTS AND ILLUSTRATIONS

The Journal publishes sound original articles, discussions, and reviews on wildlife research, management, and administration. The author (or one of joint authors) must be a member of the Society in good standing; exceptions need special approval by the Editor and President (ruling of Council, Feb. 16, 1941).

In general, papers will be published in order of receipt of copy in final form. Any requiring major changes will be returned promptly. Suitability is judged by the content of significant new material, concisely stated, with scientific accuracy and clarity of expression. If necessary, enlist the aid of a local editor or instructor in English in matters of style, grammar, and punctuation. The University of Chicago "Manual of Style" (1937), S. F. Trelease and E. S. Yule "Preparation of Scientific and Technical Papers" (1936, Baltimore, Williams & Wilkins Co.), and similar manuals are helpful aids.

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The Wildlife Society was founded on February 28, 1937. Its principal objectives are: (a) Establishment of professional solidarity and maintenance of the highest possible professional standards; (b) development of all types of wildlife management along sound biological lines; (c) publications to effect these ends; and (d) protection of the interests of its members. These purposes are served by annual meetings, regional meetings, correspondence between members, and publication of the quarterly Journal of Wildlife Management and of the quarterly Wildlife Newsletter.

Associate Membership is open to any interested person who is sponsored by two Active Members; dues are $4.00 annually. *Active Membership* (requiring election by the Council) is open to persons professionally engaged in the practice or teaching of wildlife management, in wildlife administration, in wildlife research or in graduate study of these subjects, who is a graduate of a school approved by the Council; or who, in the opinion of the Council, has acquired an understanding of wildlife work comparable to that required by an approved school; dues are $5.00 annually. *Honorary Members* are persons recognized for distinguished service or outstanding achievement in wildlife management. All classes of members receive The Journal and Newsletter. Applications for membership should be made to the Secretary.

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IN APPRECIATION OF ALDO LEOPOLD

Paul L. Errington

Professor Aldo Leopold, Chairman of the Department of Wildlife Management of the University of Wisconsin and a Past-President of The Wildlife Society, died of a heart attack near his summer home at Baraboo, Wisconsin, April 21, 1948, after two hours of fighting a bad grass fire on a neighbor's land.

I shall not here write of his personal life except in relation to his career in the professional field of wildlife management.

It is proper that he be singled out for the attention of the profession's members. Without belittling in any way his numerous contemporaries, it may be said that he, more than anyone else, has been responsible for the expansion and refinement of wildlife management as such is known today. As a measure of this, we need only consider the strategic positions that he held, the astounding amount of work that he did on committees, the insight and diligence with which he pioneered in the field, his honesty of purpose, and his inspiring and leading of youngsters and the mature alike. At a conference a couple of years ago, he was introduced as a speaker with the words, "Dean of Deans" of the profession, which might have sounded trite if applied to another, yet for him seemed wholly appropriate.

I met Aldo in the spring of 1929, when he was conducting a game survey of the north-central United States for the Sporting Arms and Ammunition Manufacturers' Institute. He was likewise the Institute's representative for a series of graduate research fellowships on game birds that it was financing at land-grant universities. I held one of these fellowships for three years, beginning July, 1929, and it happened to be with the University of Wisconsin at Madison—also the city of the Leopold home and office. As Aldo was not appointed to the University of Wisconsin staff until 1933 (a year after I had left the campus), I was never formally his student.

Informally, I moved in on him, his home, and his library for hours at a stretch, talking "shop" or anything else. I wasn't a restful satellite and sometimes argued in an evening until neither of us could sleep long after going to bed, but he was gracious toward me and patient with my ex-trapper's social deficiencies. And he was kindly insistent that, as concerned complex natural phenomena like animal fluctuations, one should first gather an abundance of facts to study rather than to put forth opinions based chiefly or solely upon outdoor experience.

He appreciated the ability and scientific outlook of H. L. Stoddard and W. L. McAtee (notably as manifested

by the southeastern researches on bobwhites and associated species), of Charles Elton, the British ecologist, of the late P. S. Lovejoy of Michigan, and of creative thinkers wherever he found them, in person or through their publications. He was one of the first in the field really to see the exceptional virtues and promise of the untalkative young Franklin J. W. Schmidt, who died in a fire just as his work on central Wisconsin prairie chickens was becoming recognized.

Aldo's own alertness and powers of synthesis were very evident from the beginning of my relations with him. Even when beset by great fatigue, he could somehow continue to think effectively. To me, one of his most impressive intellectual performances was during hospitalization for an unrecalled ailment: under stimulus of an impending deadline, he dictated whole chapters of his "Report of a Game Survey of the North Central States," published by the Institute in 1931. Later, he was characteristically dissatisfied with its loose ends, but, irrespective of these, it stands as a remarkable achievement.

In retrospect, I think not only of his personal qualities, as of the time when I knew him best, but also of his virtually undertaking, at middle age, a new profession and making this his distinguished life work after what are commonly a man's most plastic and productive years.

Aldo was born on January 11, 1886, at Burlington, Iowa, and became interested in ornithology and hunting during boyhood and youth along the Mississippi River. He was trained in forestry at Yale, receiving the degree of Master of Forestry in 1909. Thereupon, he entered the U. S. Forest Service as a Forest Assistant and worked with that organization in southwestern United States until 1924, meanwhile rising through several grades to that of Chief of Operations.

If we look over the first dozen titles (1916–19) in the Leopold bibliography compiled by J. J. Hickey (University of Wisconsin Wildlife Research News Letter, No. 35, May 3, 1948), we may see that his earlier publications were much like those any able young field naturalist might write. They were mostly notes in The Condor and a couple of papers on game in the Journal of Forestry. One of the latter dealt with the National Forests as the last free hunting grounds of the nation. In the second dozen titles, we may see more ornithological notes and articles on game and game refuges but the future crusader against politics in conservation and misuse of resources is showing up more clearly.

The listed titles from 1920 through most of 1925 are predominantly of short articles on ornithology, hunting and game management, forestry in relation to game management, erosion control, ecological consequences of forest fires, and wilderness values. Included is the one that I regard as his first great paper: "Wilderness as a form of land use," Journal of Land and Public Utility Economics, **1**: 398–404, 1925.

The latter was not his first expression of views on wilderness protection. He had published "The wilderness and its place in forest recreational policy," Journal of Forestry, **19**: 718–721, 1921, and it is plain from other of his previous writings that he was becoming much aware of the pricelessness of unexploited outdoor areas. The paper on

wilderness as a form of land use was more than a statement or plea; it was both solidly informative and a literary contribution. I cannot say how influential it proved to be, of itself; but to it, among the others, surely should be credited some of the prominence Aldo attained as an early protagonist of wilderness areas in National Forests. I read in a University of Wisconsin memorial resolution that the U. S. Forest Service subsequently designated a total of 14,000,000 acres as such areas, which are considered to "represent the most visible evidence of his [Aldo's] influence on the American scene." The Leopold writings on wilderness of around a quarter-century ago are certainly in the historical picture. They still nourish movements for the preservation of wildernesses, not alone in the United States or in North America, but over those parts of the rest of the world where men try to retain irreplaceable natural remnants.

The years, 1924–28, with a transfer to Madison, Wisconsin, to become Associate Director of the U. S. Forest Products Laboratory, comprised something of an interlude. He wrote relatively little for publication in this period, and what he did write usually dealt with forestry techniques and utilization or may be classed as carryover from his life in the Southwest.

Without knowledge of the details behind the selection of Aldo Leopold by the Sporting Arms and Manufacturers' Institute for its game surveys in 1928, one may perceive how he qualified for the job. He was experienced in administration and public contacts, his interests in game and hunting had long been demonstrated, and he had a record of constructive accomplishment in what was then known as game management. Considering the stage of development of management as a field, he was singularly informed. Already, he had contributed to the reversal of the trends toward artificial propagation or tightened legal protection as panaceas for conservation ills; he did not seek complete abandonment of either propagation or protection but rather a judicious balance for them in an incomparably more promising system based upon the ecology of the species concerned. He differentiated between passive conservation and active management and identified management with a desirable type of husbandry of the earth and its mineral and biotic resources. He was an ecologist and a specialist in his own branch of ecology.

Despite his background, the transition from his old profession to his new one had its abrupt aspects. During the 20 years that he lived as a full-time practitioner of the new profession (and particularly during the first few years), he changed emphasis in several fairly distinct ways.

The changes did not occur in sudden steps. They reflected his accelerating professional growth and the growth of the new field in applied ecology in which he was a "key" worker, the impacts of the man and of the field, of one upon the other.

His game surveys had left him with friends among game administrators, sportsmen, and conservation workers of differing creeds and purposes over the continent. As a man of reason, he kept building on the factual foundations that he had at hand—constantly trying to uncover pertinent researches that had

been done or were in progress, encouraging further research, and doing what he could by himself. He did a tremendous amount of reading on conservation history and methods, on the long-established systems of game management of the Old World. Always comparing systems, he tried critically to separate the desirable from the objectionable features of each, to dissociate sound fact from traditional assumption, to understand more of the workings of natural mechanisms.

As chairman of a large committee, he did much of the work of preparing the "Report to the American Game Conference on an American Game Policy," Transactions of the American Game Conference, **17**: 284–309, 1931, which mentioned the incompatibility of the English and American systems of game management. "Game methods; the American way," American Game, **20**: 20, 29–31, 1931, was written "to express a personal view of what the policy means in its references to the European practices." In this, the theorem was advanced that "to supply any given proportion of the population with any given amount of game, Europe must raise a denser stand of game per acre, and hence practice a more intensive form of game management than America." Quoting further: "The recreational value of a head of game is inverse to the artificiality of its origin, and hence in a broad way to the intensiveness of the system of game management which produced it. . . . A game policy should seek . . . between the evident necessity of some management and the aesthetic desideratum of not too much. . . . There is nothing to prevent us from adopting the European technique for producing a game crop, and at the same time rejecting the European customs governing the intensity of the operation and the European system for its harvesting and distribution. The game policy, by and large, proposes just this . . . ."

He went on in the same article to challenge "the ruthless suppression of predators which goes with game management in most European countries. W. T. Hudson has voiced his protest over the disappearance of one predatory species after another, and his resulting contempt for the aesthetic horizon of sportsmen and sportsmanship . . . American protectionists mortally hate and fear the impending (?) American counterpart of this sacrifice. . . .

"I am no prophet. I would point out, however, that stringent predator control is usually unnecessary save in the upper scale of intensive game management . . . we do not need that kind of management. . . . This is not to say that no predator control is needed. It does mean that extensive or low-grade management—enough, let us say, to quintuple our crop—can best be achieved by light, local, seasonal and selective handling of the predator-factor. . . . Is it too much to hope, then, that the group-cooperative wild life enterprise advocated by the game policy may ultimately evolve an American attitude toward predators, based on the new biology, and recognizing the nature-lover and farmer, as well as the sportsman, as joint partners?"

In what could almost be called a companion piece—"Game and wildlife conservation," Condor, **34**: 103–106, 1932—he drew other important distinctions that the reader could afford to

study. Very significant is that between the "schools" of "hardened sportsmen" in this country, exemplified by moderate and extreme factions.

But perhaps nowhere so well as in the concluding paragraphs of the celebrated textbook, "Game Management" (Scribners, 1933), does he clarify his reasoning. From his pages 420–423:

"The game manager manipulates animals and vegetation to produce a game crop. This, however, is only a superficial indication of his social significance. What he really labors for is to bring about a new attitude toward the land.

"The economic determinist regards the land as a food-factory. Though he sings 'America' with patriotic gusto, he concedes any factory the right to be as ugly as need be, provided only that it be efficient.

"There is another faction which regards economic productivity as an unpleasant necessity, to be kept, like a kitchen, out of sight. Any encroachment on the 'parlor' of scenic beauty is quickly resented, sometimes in the name of conservation.

"There is a third, and still smaller, minority with which game management by its very essence, is inevitably aligned. It denies that kitchens or factories need be ugly, or farms lifeless, in order to be efficient.

"That ugliness which the first faction welcomes as the inevitable concomitant of progress, and which the second regretfully accepts as a necessary compromise, the third rejects as the clumsy result of poor technique, bunglingly applied by a human community which is morally and intellectually unequal to the consequences of its own success. . . .

"Herein lies the social significance of game management. It promulgates no doctrine, it simply asks for land and the chance to show that farm, forest, and wild life products can be grown on it, to the mutual advantage of each other, the landowner, and of the public. It proposes a motivation—the love of sport—narrow enough actually to get action from human beings as now constituted, but nevertheless capable of expanding with time into that new social concept toward which conservation is groping.

"In short, twenty centuries of 'progress' have brought the average citizen a vote, a national anthem, a Ford, a bank account, and a high opinion of himself, but not the capacity to live in high density without befouling and denuding his environment, nor a conviction that such capacity, rather than such density, is the true test of whether he is civilized. The practice of game management may be one of the means of developing a culture which will meet this test."

His other writings for this period contain other syntheses of complex subject matter, other pace-setting thought, other excellent composition; and two "heavy" essays, "The conservation ethic," Journal of Forestry, **31:** 634–643, 1933, and "Conservation economics," Ibid., **32:** 537–544, 1934—two of his greatest papers. Among the major changes in professional emphasis to be detected in his publications, 1929–35, is one from the survey to the intensive method of research and another from game management for shooting to far broader versions of management involving native prairie flowers and songbirds as well as game and game habitats. These changes doubtless may be

ascribed partly to changed conditions of employment, notwithstanding which there is plenty of evidence that Aldo's own inclinations led him into them.

In 1935, he studied German game and forest management under a Carl Schurz Travelling Fellowship, publishing his comparisons and conclusions chiefly during the next year: the two-part paper, "Deer and Dauerwald in Germany," Journal of Forestry, **34:** 366–375, 460–466, and semipopular articles in Bird-Lore and American Wildlife. This trip, by its contrasts, intensified his concern for threatened outdoor values—see, for example, the introduction to the Bird-Lore article, "Naturschutz in Germany," in which he depicted the "nostalgia of the German for wildness, as distinguished from mere forests or mere game. . . . We Americans yearn for more deer and more pines, and we shall probably get them. But do we realize that to get them, as the Germans have, at the expense of their wild environment and their wild enemies, is to get very little indeed?"

We have in 1937 the appearance of superbly written short essays, combining ecology and management and a philosophy of esthetics. "Conservationist in Mexico" and "Marshland elegy," both appearing in American Forests (**43:** 118–120, 146, and 472–474), are, I feel, among the first of the fully mature Leopoldian essays of this type. More came out in subsequent years, such as: "Conservation esthetic," Bird-Lore, **40:** 101–109, 1938, "A biotic view of land," Journal of Forestry, **37:** 727–730, 1939, "Escudilla," American Forests, **46:** 539–540, 1940, "Song of the Gavilan," Journal of Wildlife Management, **4:** 329–331, 1940, "Cheat takes over," The Land, **1:** 310–313, 1941, "The last stand," Outdoor America, **7**(7): 8–9, 1942, "The Flambeau," American Forests, **49:** 12–14, 47, 1943, "Wildlife in American culture," Journal of Wildlife Management, **7:** 1–6, 1943, "The green lagoons," American Forests **51:** 376–377, 414, 1945, and "The ecological conscience," Bulletin of the Garden Club of America, September: 46–53, 1947. A book of his essays, including his revisions of some of the above, is to be published in 1949 by Oxford University Press, N. Y.

To some degree, his later publications reflect changed emphasis, as from advocating monetary or other economic incentives for management to attempting to inculcate appreciation for cultural values. They also indicate a change in emphasis from training of specialists to liberal education as a means to management ends. Aldo worked for long-term "deep-digging" research up to the time of his death, but he saw long before then that the problems of sane land use required more than the attention of professionals. There had to be better motivated, better directed, and better sustained participation by the public if what was good in management was to become a living practice.

As scientist or educator, he was anything but jealous of professional prerogatives. From "Wildlife in American Culture" (his page 5):

"Wildlife research started as a professional priestcraft. The more difficult or laborious problems must remain in professional hands, but there are plenty of problems suitable for all grades of amateurs. . . . Ornithology, mammal-

ogy, and botany, as now known to most amateurs, are but kindergarten games compared with researches in these fields. The real game is decoding the messages written on the face of the land. . . .

"Few people can become enthusiastic about research as a sport because the whole structure of biological education is aimed to perpetuate the professional research monopoly. To the amateur is allotted only make-believe voyages of discovery, the chance to verify what professional authority already knows. This is false; the case of Margaret Nice proves what a really enterprising amateur can do. . . . " (He delighted in the ornithological investigations of Mrs. Nice, which in volume and quality surpassed so much of the work of the professionals.)

Long ago, he had likened the titles of academic courses to labels on bottles having highly variable contents; and, coming from him as a teacher of academic coursework, his paper, "The role of wildlife in a liberal education" (Transactions of the North American Wildlife Conference, **7:** 485–489, 1942) has quotable paragraphs:

"Liberal education in wildlife is not merely a dilute dosage of technical education. It calls for somewhat different teaching materials and sometimes even different teachers. The objective is to teach the student to see the land, to understand what he sees, and enjoy what he understands. I say land rather than wildlife, because wildlife cannot be understood without understanding the landscape as a whole. Such teaching could well be called land ecology rather than wildlife, and could serve very broad educational purposes.

"Perhaps the most important of these purposes is to teach the student how to put the sciences together in order to use them. All the sciences and arts are taught as if they were separate. They are separate only in the classroom. Step out on the campus and they are immediately fused. Land ecology is putting the sciences and arts together for the purpose of understanding our environment. . . .

"There is no need to persuade the student of land ecology that machines to dominate the land are useful only while there is a healthy land to use them on, and that land-health is possibly dependent upon land-membership, that is that a flora and fauna too severely simplified or modified might not tick as well as the original. He can see for himself that there is no such thing as good or bad species; a species may get out of hand, but to terminate its membership in the land by human fiat is the last word in anthropomorphic arrogance."

From the paper, "Wildlife in American culture": "Ecology is now teaching us to search in animal populations for analogies to our own problems. The ability to perceive these, and to appraise them critically, is the woodcraft of the future."

Aldo's personal contacts with students were quite evidently similar to what they had been with me during his game survey years. I learned from "grapevine" that he exhorted them to write carefully, to revise their manuscripts over and over until organized and smooth, to strive for the maximum simplicity consistent with the subjects written upon. The summer after leaving Wisconsin, I brought back to him a

medium-length manuscript on the different versions of which I had labored for four months and which I considered ready for the editor; we worked for two days at high pressure, and it took six weeks more of revision to incorporate his suggestions—and that wasn't any too long!

His students, too, could hardly have missed his fairness and what Elton (letter of May 4, 1948) called a "special sort of integrity." My data were always mine, and I have no doubt that his students were assured that their data were theirs and that they could as a matter of course expect a reasonable amount of professorial guidance in handling the same—actually, he was generous with his time to the extent that it frequently meant hardship to him. Nor do I doubt that at least his more mature students respected his intellectual humility.

I remember other things about him from the earlier years. I remember him as a man in the personal crisis of being without income for months during 1932 and 1933 in the worst of the Depression. He took this punishment most creditably, kept up the standard of living of his family as well as circumstances allowed, worked on the manuscript of "Game Management," and made plans with courage and realism. He was offered desirable positions, including a professorship at a prominent state college, but these would have entailed moving his home from Madison, which he was reluctant to do. Then, the University of Wisconsin established its first Chair of Game Management, later becoming the Department of Wildlife Management.

In appraising Aldo's accomplishments, I would rate the literary essays as the greatest. They reflect him and his thoughts, what McAtee (letter of May 3, 1948 to R. A. McCabe) referred to as "his lucid and stimulating discussions in the conservation field . . . his ever growing power as a writer." In this, his own field of excellence, I don't think that anyone else may be compared with him.

His scientific best is, I think, illustrated by his papers on forest game and land use. These have appeared in widely scattered journals, but the Journal of Forestry drew the larger proportion.

His personal inspiration of others is hard to do justice to, whether this was in routine dealings with students or public, or in strategic committee work. As regards his committee work alone, one must consider not only the dozens of committees of scientific societies and conservation organizations to which he was appointed but also those of extraordinary prestige and importance, such as his chairmanship of the committee on wildlife studies of the National Research Council. Shortly before his death he had been asked by Secretary of State Marshall to be a discussion chairman at the Inter-American Conference on Conservation of Renewable Natural Resources and by Secretary of the Interior Krug to serve on the Advisory Committee on American Participation at the United Nations Scientific Conference on Conservation and Utilization of Resources.

* * *

In order to write this memorial as reflectively as I could, I waited until my vacation to do it, to do the writing in a simple log dwelling house near one of National Forests.

A porcupine-girdled pine top may be seen through the front windows, and just out of sight hang the remaining sticks of a goshawk nest that had young in it twelve summers ago. Three species of grouse live along the creek that comes down out of the canyon. If one looks, one may easily find deer and bear "sign" and, in the hours of darkness, coyotes howl. The air smells richly of pine and sage.

The property on which the log house is situated contributes to the livelihood of people. Along with the "sign" of native animals is some of horses and cattle. Some land is tilled and some yields hay. Yet, the tract surrounding the house is wild and it is intentionally kept so. We are getting rid of the old stumps and other axe-marked wood; our two boys bring it in to burn in the box stove. A large yellow pine with weakened base that we once had to take down to protect the house is an exception: its trunk will be left where it fell, axe and saw cuts and all, ungrudgingly. For a ruffed grouse has accepted it as a drumming log, and, in the twilight of evening or early morning, if careful, the family may watch and hear the muffled beating of wings—that "numenon" of northern woodlands. This, I am sure, Aldo would have approved as husbandry.

To the west, the National Forest begins. Less than ten miles away is timberline and, below that, are still-occupied retreats of those much reduced prize fur-bearers, the martens. In the canyons farther below, glacial waters pour over and between boulders, and there are bobcat or lynx tracks in the mud where a game trail leads around a beaver pond. Deep in the forest are said to be a few grizzly bears and even cougars.

The thought of Aldo in connection with this mountain wilderness seems appropriate, though I doubt that he had ever seen it. The love he felt for the out-of-doors and the things that belonged in it was not a matter of geographical boundaries, nor confined to particular settings. In his essay, "Conservation esthetic," he wrote: "To those devoid of imagination, a blank space on the map is a useless waste; to others, the most valuable part. (Is my share in Alaska worthless to me because I shall never go there? Do I need a road to show me the Arctic prairies, the goose pastures of the Yukon, the Kodiak bear, the sheep meadows behind McKinley?)"

* * *

Very probably one so distinguished will be honored posthumously in many ways. There is talk of a memorial fellowship and there may be other movements to perpetuate his name and ideals. Assuredly, these should be encouraged and supported to the extent that they are well-conceived. We must not mock honesty with gestures. I can imagine his gentle scorn at the thought of anything like elaborate statuary in his memory while despoliation and wastage of the land and its biota continue as usual.

For, his greatness, as I regard it, lay in the fact that he loved and worked and fought for something greater than himself or any other man. He knew of the peace that outdoor values may give to receptive minds and he wanted those values safeguarded and increased for others as well as for himself. However else it may be designated, his concept of what is worth living in human life

has a certain agelessness to it, a solidarity beyond the creative power of any one man. His sense of responsibility and decency is likewise much more than the byproduct of any one man's thinking.

Let no one do him the disservice of fostering Leopoldian legends or Leopoldian dogmas. Knowing him as I have, I can say that he would not wish them to arise from his having lived. He would not wish to have imputed to him any qualities or abilities that he did not possess. He was only a mortal man, but a highly civilized and intelligent one withal, literate and—most fortunately—articulate in those ways necessary to convert intentions into leadership.

In some respects, we might look upon wild beauty, as such, whether in back yard or in remote places, a most fitting memorial to him and to his kind. As his professional colleagues, let us recognize our obligations to a philosophy of living that has goodness in it beyond selfish objectives; and, moreover, that we honor him according to the way we, ourselves, live and lead.

MARSH-BLASTING AS A WILDLIFE MANAGEMENT TECHNIQUE

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INTRODUCTION

It is now commonly agreed that wildlife values in marshes are largely dependent upon a favorable balance of cover and open water. This has been called the interspersion factor (Low, Scott and Dever, 1941). Although avian responses to varying degrees of interspersion have not been actually measured, much circumstantial evidence supporting the relationship is available. Except in the case of diving ducks, where Low (1945) described the use of open water areas as bases for nesting operations and as take-off and alighting areas, the nature of this interspersion requirement remains little understood. Probably there is more involved than mere "edge effect," even though this be interpreted in terms of diversification of food production. On the basis of territorial behavior in ducks as described by Hochbaum (1944), the nest potential of a marsh should be proportional to the ratio of cover-water edge to cover area, an obvious involvement of interspersion. Other special services of interspersion to various forms of marsh wildlife may eventually be demonstrated. Nevertheless, there is here involved an environmental complex of which water depth, cover type, and cover density, as well as interspersion, are only different aspects; any one is nearly always conditioned by the others (Provost, in press). In some cases, therefore, interspersion may be merely the result of interaction of other de-

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sirable factors, in which case it would be more an indicator than an actual requisite of adequacy in the environment. Until its exact nature has been demonstrated, interspersion hypothetically can be considered an ecological factor in the marsh environment. Studied in this light, it may be used as a base upon which to orient many phrases of the intricate relationship between animal and habitat in the marsh.

Natural interspersion is ordinarily created, modified, or maintained through the agency of several influences, foremost among which are water levels and muskrat activity. Where neither water level manipulation nor muskrat activity can be relied upon to open up dense covers, it may be desirable to resort to artificial means of improving cover-water interspersion. This thought led Scott and Dever (1940) in 1939 to attempt blasting as a means to this end. Later, an intensive investigation of the techniques was undertaken in Iowa. This report will concern itself primarily with the physical aspects of dynamiting in marshes, the ultimate objective being the formulation of the most adaptable and most efficient methods for creating the desired interspersion by blasting.

EXPERIMENTAL AREAS

In reporting the pioneer work done at Little Wall Lake in Hamilton County, Iowa, Scott and Dever (1940) described the area as a 230-acre marsh near Jewell, Iowa, grown up to a dense *Scirpus-Typha* (bulrush-cat-tail) community. In 1941, when follow-up studies were made, the marsh was essentially unchanged. Since then, water levels have risen five feet or more to completely fill the basin, inundate the experimental excavation, and reduce the solid cover to a thin stand of bulrushes on approximately 40 per cent of the lake's area. The lake bottom is deep peat, underlain by a shallow clay hardpan only about the periphery. The blasting was done partly over this clay and partly over deep peat (Figure 1).

In the spring of 1940 and in the fall of 1941, blasting was done in a state-owned tract of marsh adjoining Mud Lake in Palo Alto County, Iowa. This Oppedahl Tract (Figures 2 and 3) has changed little since 1940. It is a sedge marsh, dominated by lake sedge (*Carex lacustris*). Half of the marsh has a sizable intermixture of broad-leaved cat-tail (*Typha latifolia*) and river grass (*Fluminea festucacea*), and several small patches of hard-stemmed bulrush (*Scirpus acutus*) and great bur-reed (*Sparganium eurycarpum*). Except for a channel crossing the tract in the northwest sector and a small natural opening along the mid-southern boundary, it is virtually solid marsh cover. In an average year, water stands up to 12 inches over the marsh in the spring and recedes to several inches below the ground level by late summer. The soil is mainly peat to a depth of over six feet. Areas marginal to upland are underlain by a blue clay sloping from two feet underground at the edge to six feet down approximately 100 yards from shore.

In the fall of 1941, experimental blasting was carried on also in the ponds of Dewey's Pasture (Figure 4), a 403-acre, state-owned tract of prairie dominated by bluegrass, dotted with over 50 kettle-holes ranging in size up to 13 acres. This area is north of Mud

Lake in Clay County, Iowa. The ponds are all less than four feet deep. The bottoms are peat and muck for about three feet. Below this "mud" there generally occurs a very hard substrate of either pure blue clay or a sandy clay in which is incorporated a quantity of shells and pebbles. The vegetation of these ponds

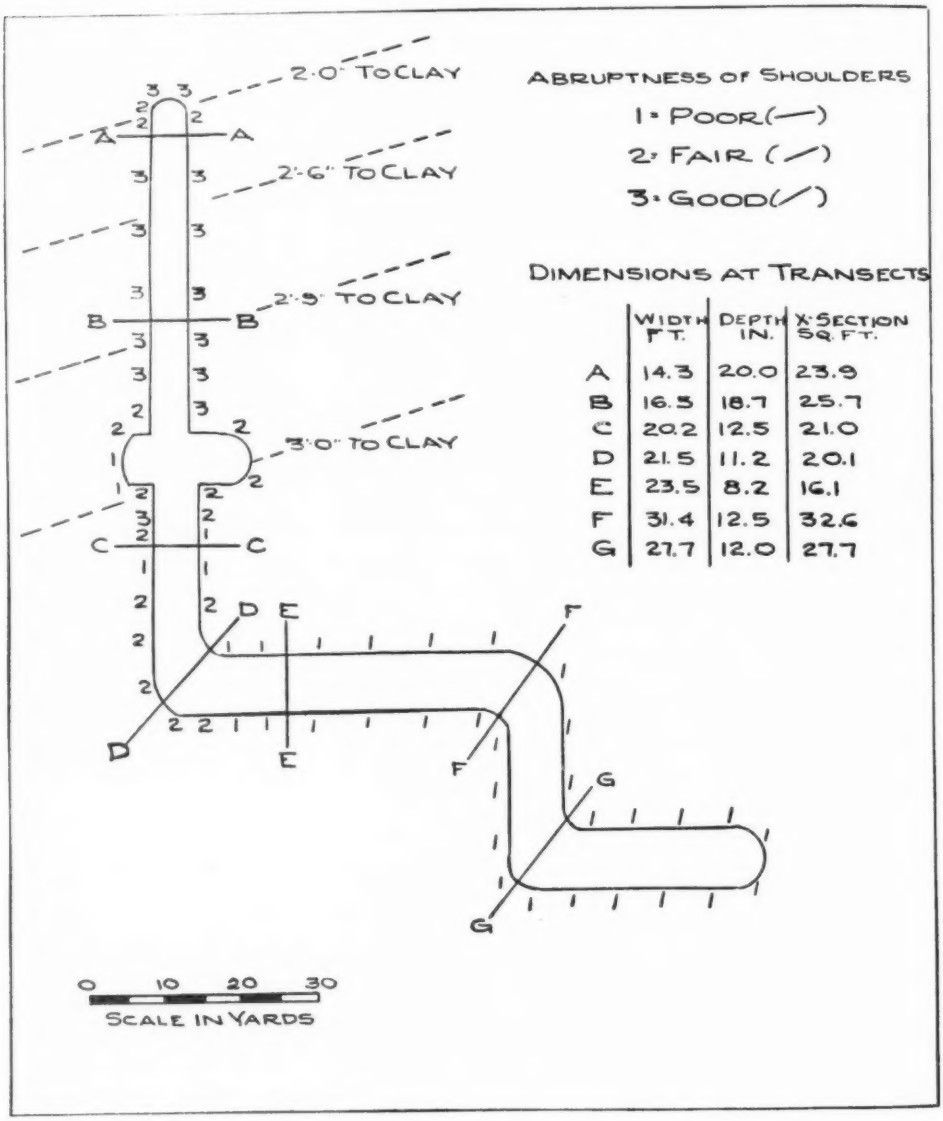

FIG. 1.—Measurements of Little Wall Lake excavation, July 1941, when two years old. The effect of depth to clay hardpan is reflected in cross-sectional area, depth, width, and in abruptness of shoulders.

varies through the years in response to changes in water levels. In the deeper waters, round-stemmed bulrushes (*Scirpus acutus* and *S. heterochaetus*), cattails (*Typha latifolia* and *T. angustifolia*), and great bur-reed predominate, while to landward a progression of vegetation zones leads through various

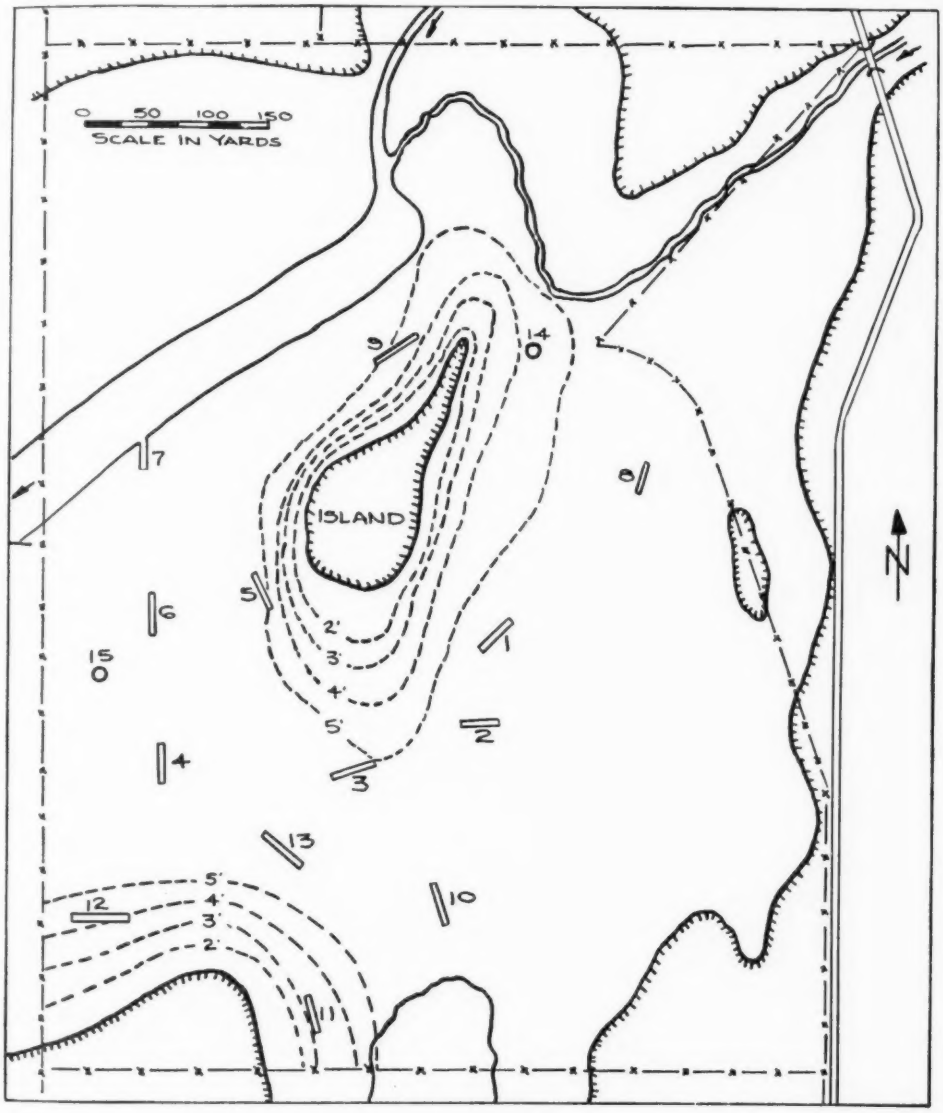

FIG. 2.—Location of clearings in the Oppedahl Tract marsh. Open water is restricted to creek north and west of island and to a low area on the southern boundary. Dotted lines are contours of depth below surface to clay hardpan.

sedges (*Carex* spp.) or river grass to slough grass (*Spartina pectinata*) or blue-point grass (*Calamagrostis inexpansa*) at the edge of the bluegrass. The ponds vary greatly in cover interspersion. The dynamiting was done only where the cover was solid. In contrast to the Oppedahl Tract, most of

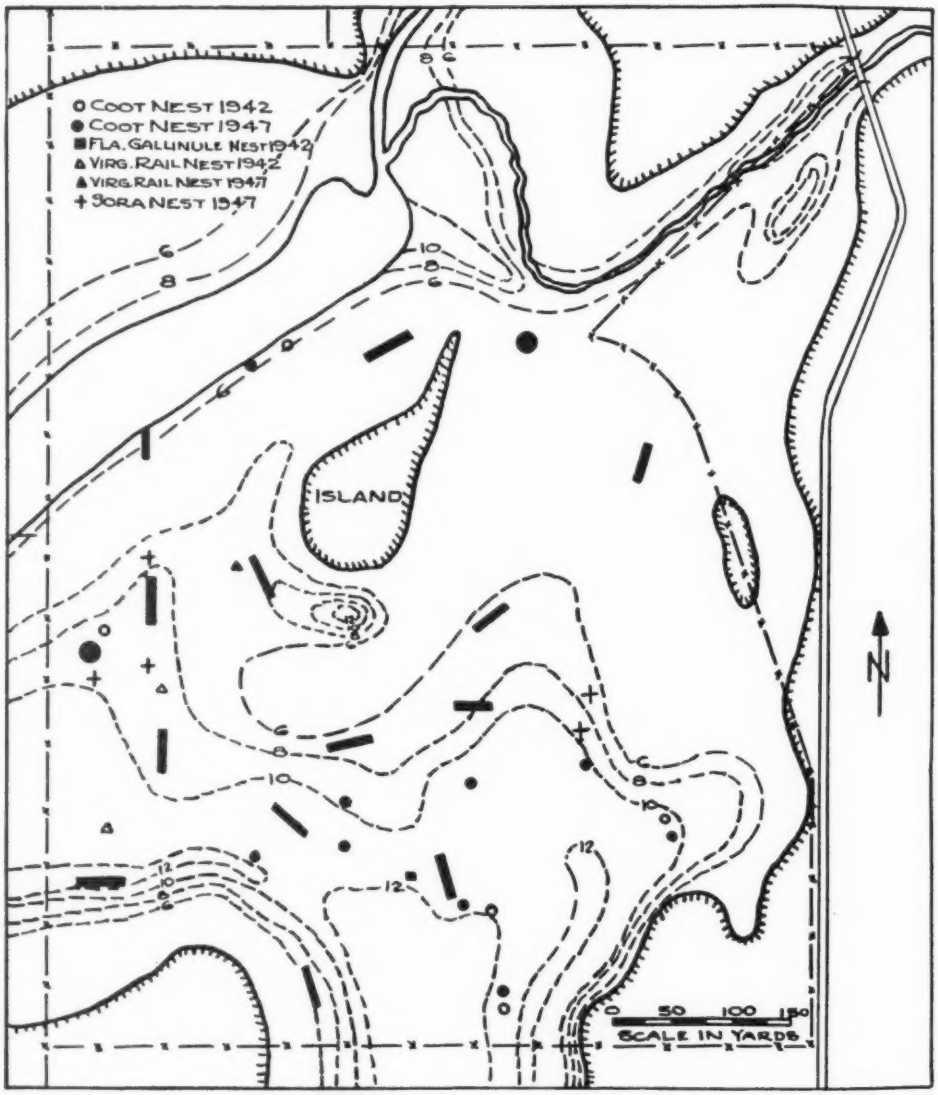

FIG. 3.—Distribution of clearings and nests in the Oppedahl Tract marsh as related to bottom topography. Dotted lines are depression contours in inches.

the blasting was done here in the deep-water emergent zone (*Scirpus-Typha*) rather than in the shallow-water emergent zone (*Carex-Fluminea*). In this respect it resembled more the Little Wall Lake experimental area.

INVESTIGATION METHODS

Preliminary to the planning of a blasting schedule for 1941, three maps of the Oppedahl Tract and Dewey's Pasture were prepared. The first was a detailed vegetation map. The second

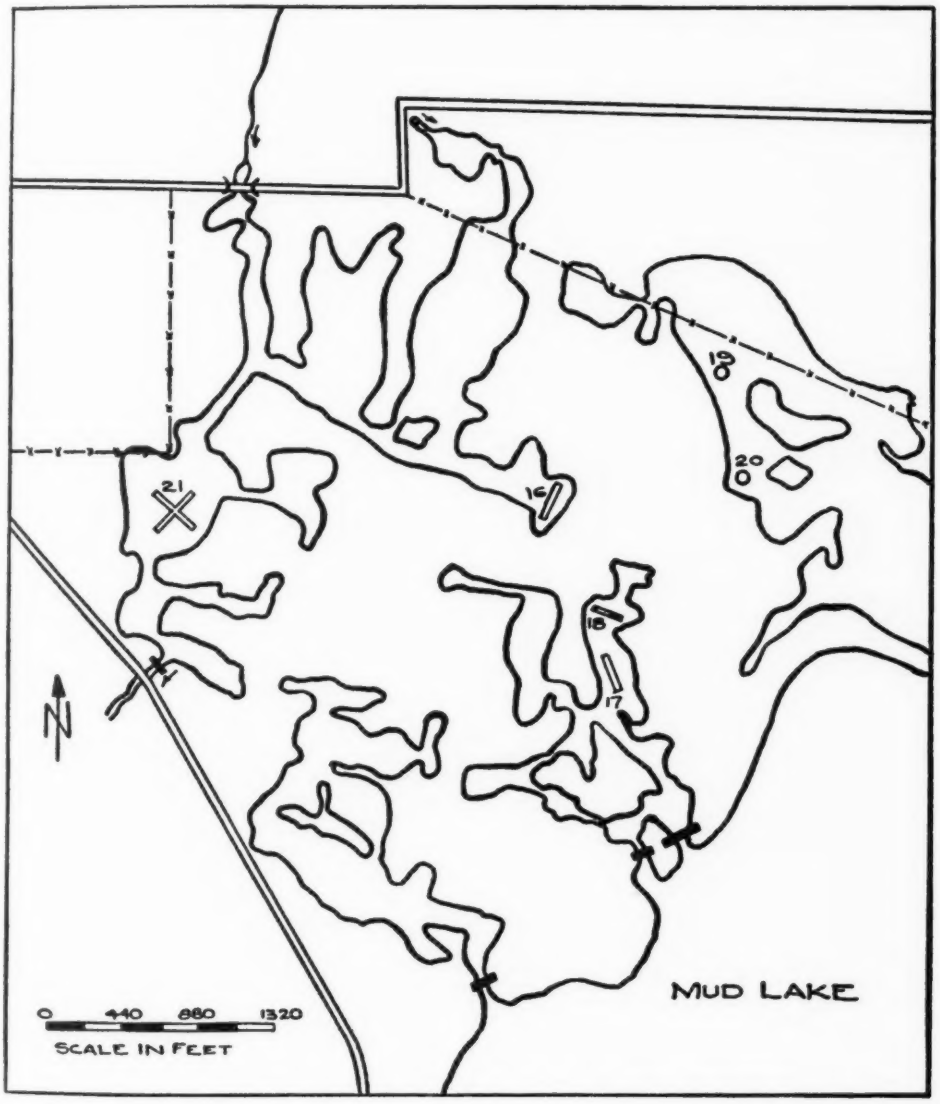

FIG. 4.—Location of clearings in the ponds of Dewey's Pasture.

was a map showing the contouring as calculated from water table studies (e.g., Figure 3). The third map was designed to show the distribution of bottom soil types, emphasizing the presence and depth of hard substrates. A six-foot soil auger was used in the many borings required. In the blasting schedule then prepared, specifications were drawn to present as many experimental variables as possible.

Prior to the actual blasting, the sites were cleared of vegetation with brush hooks or scythes. The proposed charging lines were staked off and marked. Plank walks were thrown across the "soupier" parts of the marsh for access to blasting sites. These preparations enabled the loading crew to proceed with its work immediately on reaching the site with equipment and supplies.

All ditch blasting was done by the propagation method; charges were so spaced that the detonation of one capped cartridge was propagated from charge to charge through the saturated mud, exploding the entire load almost simultaneously. Because of the saving in caps, the propagation method is definitely the economical method to use wherever the ground is saturated. In line charges, end sticks were primed with No. 6 electric blasting caps from which lead wires extended to the battery detonator. Although one cap usually suffices for one loading, where spacing of charges approaches the maximum for propagation, as in multiple-line charges, it is wiser to use a few extra caps than to risk a partial detonation. In post-hole charges each bundle of sticks was primed and the lead wires connected in series to the battery detonator.

In 1940, charges were all of one line, with only slight variations on the "3 sticks every 2 feet" method. Charging methods employed in 1941 are indicated in Figures 5 to 8. Two basic methods were used, with variations as shown. One was the "line charge," where from one to four cartridges per hole were placed in straight lines to produce "ditches." Either a T-punch bar or a broom handle was used to bore a hole in the mud. The sticks were pushed in with the broom handle, one on top of the other, until the top of the topmost stick was 18 inches below the surface. Variations in depth of charges were tried at Little Wall Lake and in the Oppedahl Tract and the indication was always that 18 inches was the best depth. The load side was then tamped down firmly under foot. Experimentation with spacing of charges in a row showed two feet to be ideal. Where the individual charges are of two sticks, spacing should be reduced to 18 inches and where they are four sticks, spacing may be increased to 30 inches. But for maximum efficiency in propagation and excavation, two feet for ordinary loads is the best spacing. Multiple rows may be separated by two to four feet, and a stick or two should be set between rows to insure simultaneous propagation. Two rows of three sticks every two feet, when set four feet apart (Clearing No. 9, Figure 7), left a 20-inch ridge down the center of the excavation. In two months this ridge had settled to four inches and probably disappeared in another two months. Because an interval of four feet between rows produces a much wider excavation than one of two feet (Figure 7), it is recommended for two-line charges.

The second basic charging method was the "post-hole charge" (Plate 10A). In this case, holes were dug with common post-hole diggers to a depth of four feet. Bundles of cartridges, usually 20 sticks, were placed on the bottom of the holes, which were then filled and tamped down. Each bundle was primed. The charges were usually placed six feet apart in the shape of a cross, to produce

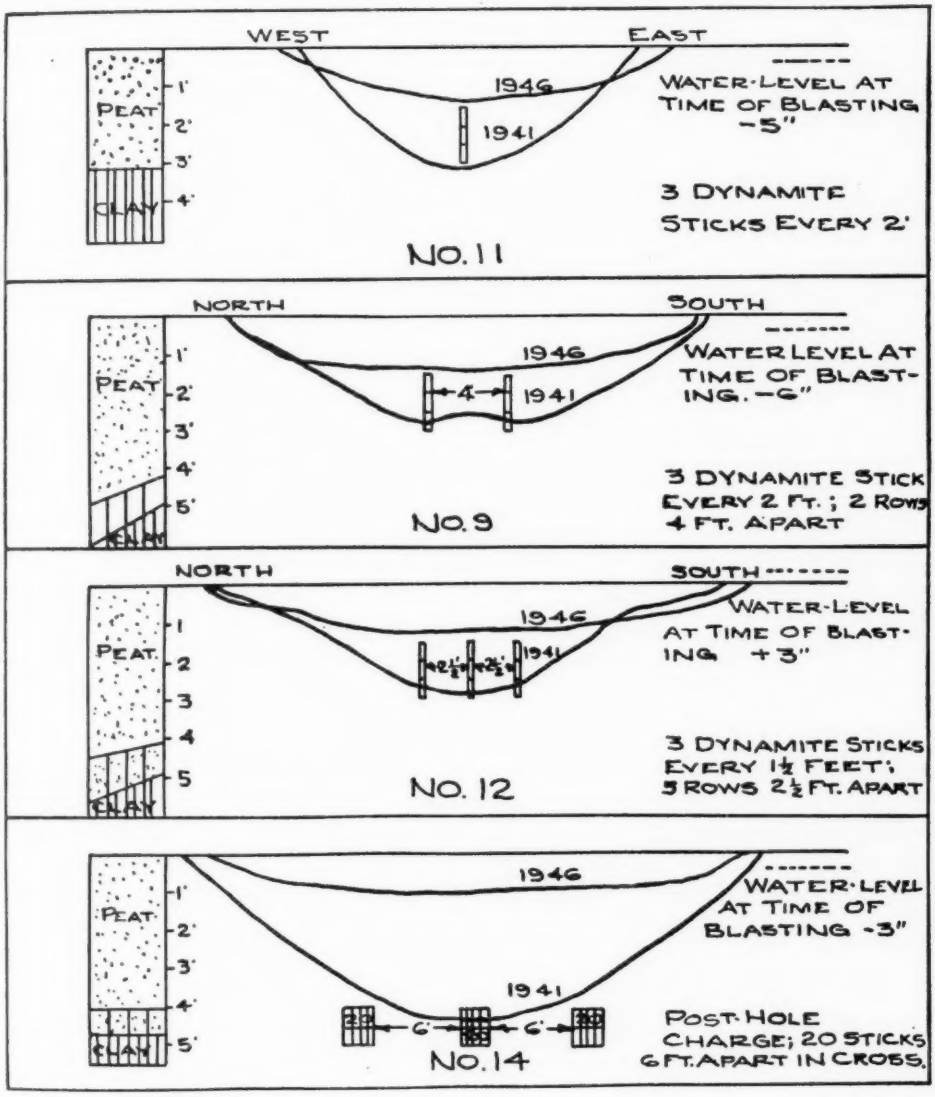

FIG. 5.—Cross-sections of typical 1-line, 2-line, 3-line, and post-hole clearings in 1941 and 1946.

round or oval pond holes. This spacing left small ridges which were indication that greater spacing with these 20-cartridge charges would have been inefficient. In Clearing No. 20 (Figure 8), a second loading of 63 sticks in the center was fired for additional depth.

The size of individual charges largely determines the initial depth of excavation. Because one or two sticks to a charge did not excavate much over 30 inches, most of the experimentation

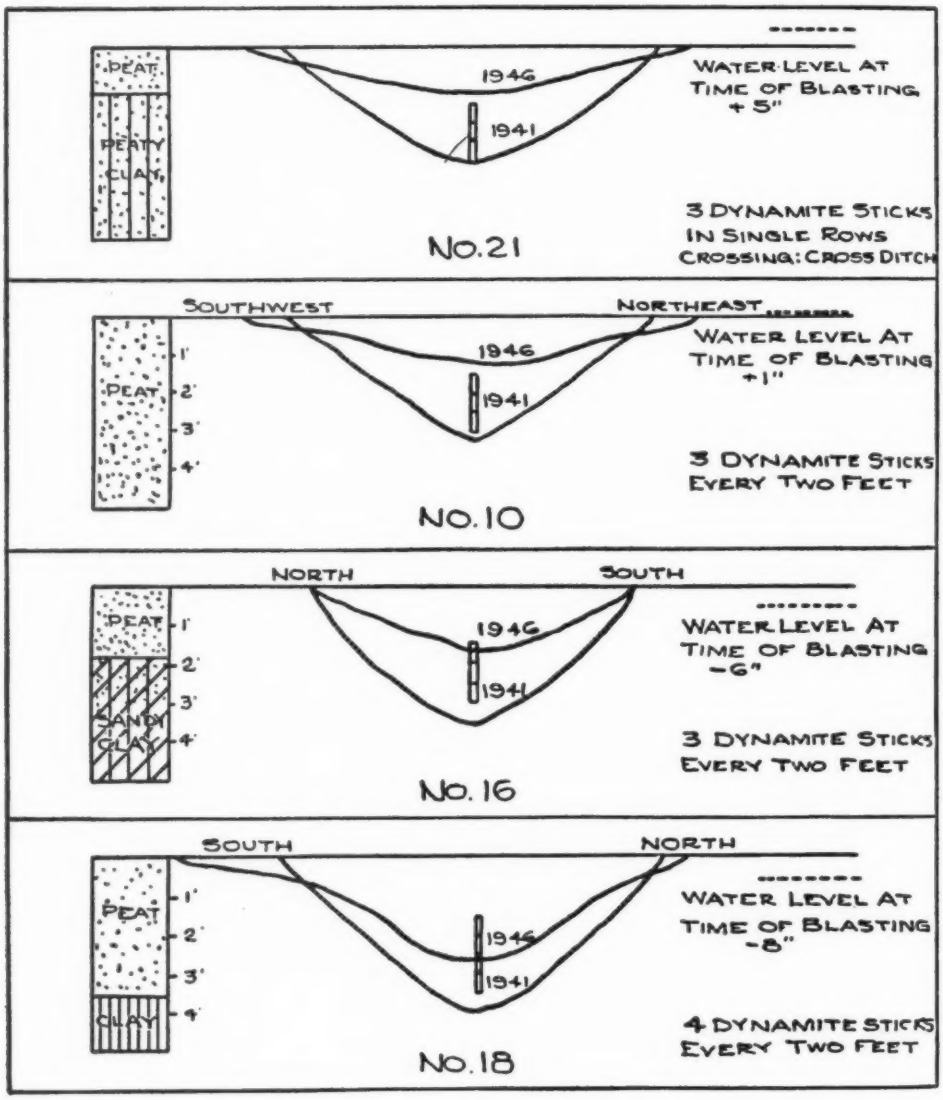

FIG. 6.—Cross-sections of 1-line clearings, 1941 and 1946, to show variation in rate of sedimentation.

was with larger loads which reached depths more promising as "clearings."

Throughout these experiments Du-Pont dynamite was used. In the fall of 1941, three varieties of dynamite were employed: 50 per cent nitroglycerine straight (or "ditching") dynamite, 40 per cent "Red Cross" Extra dynamite, and 60 per cent "Red Cross" Extra dynamite. The ditching dynamite, being more sensitive, is better adapted to propagation and it alone was used in

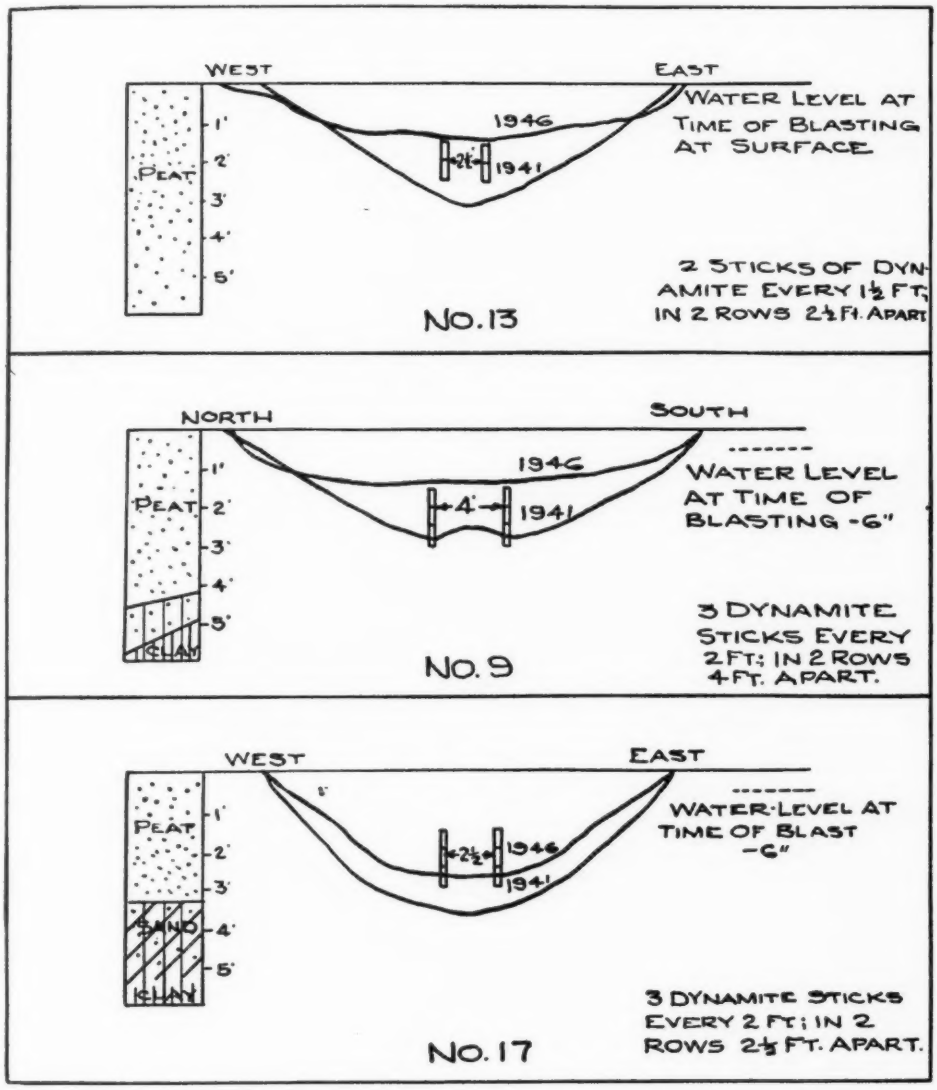

FIG. 7.—Cross-sections of 2-line clearings, 1941 and 1946, showing variations in rate of sedimentation.

line charges. Post-hole charges Nos. 14 and 19 were loaded identically (Figures 5 and 8) and in similar soil and water conditions, but No. 14 employed 40 per cent Red Cross dynamite and No. 19 50 per cent straight dynamite. The excavation rates were almost identical: 0.78 and 0.76 cubic yard per cartridge. Since the 40 per cent variety was 17 per cent cheaper (as of 1941) than the 50 per cent, a saving is indicated in the use of the former where post-hole charges are planned. Experiments with the 60 per cent Red Cross dynamite were in-

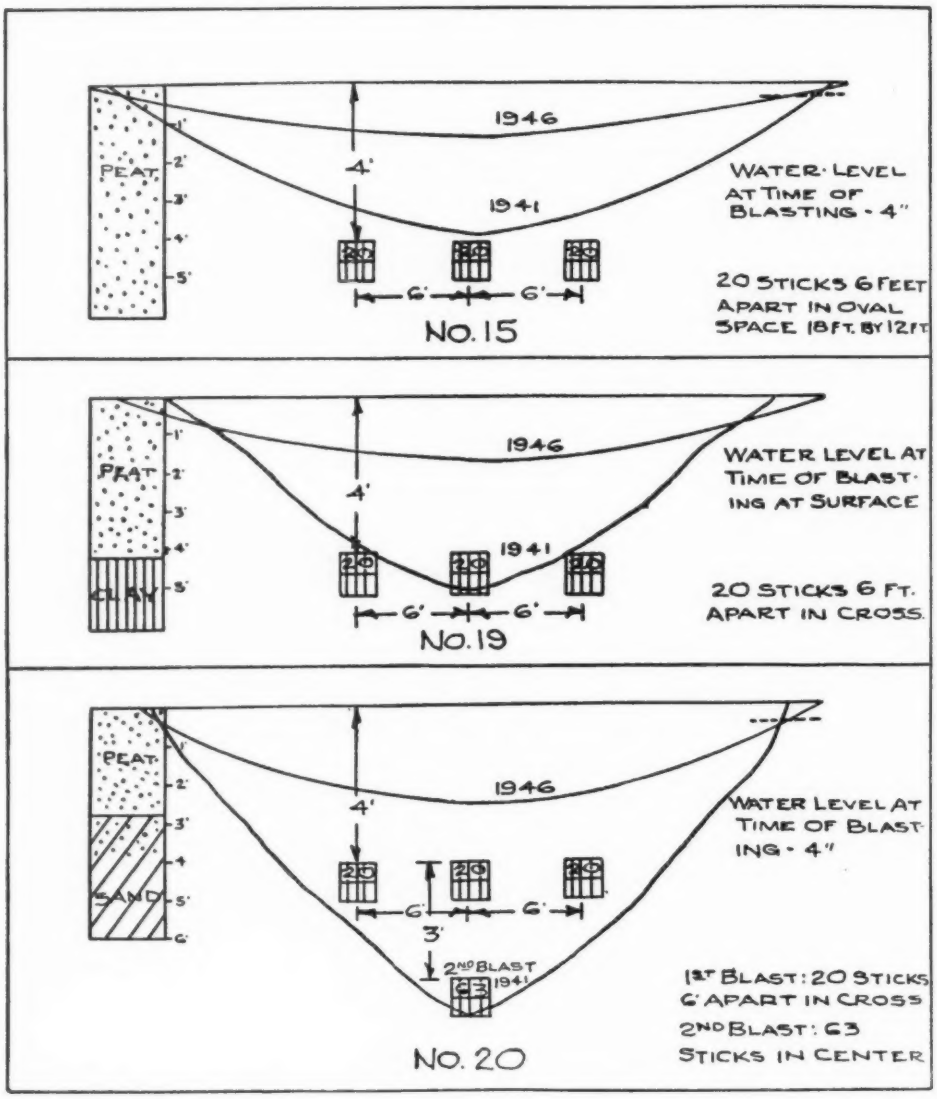

FIG. 8.—Cross-sections of post-hole clearings, 1941 and 1946.

conclusive due to other experimental variables. Since the 60 per cent Red Cross dynamite is 28 per cent more powerful than the 40 per cent (DuPont, 1942) and the cost is (as of 1941) only 7 per cent more, the 60 per cent dynamite should be more economical to use in post-hole charges.

All excavations were measured in the fall and winter of 1941 and 1946. The author took all measurements, using the same technique at all times. A carpenter's line, attached to sturdy stakes, was stretched over the excavation and drawn level with a line level. Readings in inches below the line to the ground were taken at foot intervals across the ditch and into the marsh 20 or more feet on either side. Profiles were then drawn on cross-ruled paper from these measurements. Two or more profiles (12 in Clearing No. 21) were drawn for each clearing, and the average was used in calculating cross-section areas, average depth, and volume. Fall measurements were checked within two months by taking rows of soundings through ice down the length of the ditches. In calculating depths and volumes, only that portion of the cross-section below the average marsh level away from the ditch was used, never the section below the bank tops. For straight ditches the following formula was employed for volume of excavation:

$$V = \frac{(L - A)X + AX}{27}$$

where

V = volume in cubic yards
L = total length in feet
A = length of slope to bottom in feet
X = average cross-section in square feet.

The volume of round or oval clearings was computed as surface area multiplied by average depth as determined from rows of measurements across several diameters.

For purposes of comparison, it is convenient to discuss excavation rates in terms of cubic yards of earth removal per cartridge of dynamite, assuming then a standard cost per cartridge used. The man-hours of labor involved in 1940, when 1,199 cartridges were used, totaled 90 for a labor rate of 13.3 sticks per man-hour. In 1941, when almost three times as much dynamite was used, the labor rate was 26.6 sticks per man-hour. It should be expected that the greater the volume of work of this nature, the lesser will be the unit labor cost. In round numbers, the cost in 1941 was 8½¢ per stick for the dynamite and 2½¢ per stick for labor—for a total of 11¢ per stick of dynamite used. Since the average excavation rate was 0.62 cubic yard per stick, the average cost was then 17.8¢ per cubic yards, based on remaining excavation after two months of settling of the soil. The initial excavation cost was probably 15¢ per cubic yard or less. This approaches closely the cost of similar work with dynamite in Utah (Low, in Utah Coop. Wildl. Res. Unit., 1947) where the average excavation was 0.66 cubic yard per stick of dynamite.

BLASTING EFFICIENCY

Initial excavation is, properly, the volume of excavation immediately following the blast and is the figure which should be used in determining blasting efficiency. It is a figure difficult to obtain, because the site is left in such a muddy and unstable condition (Plate

TABLE 1.—PHYSICAL MEASUREMENTS OF CLEARINGS 1 TO 21, TAKEN IN 1941 WHEN CLEARINGS 1 TO 8 WERE 18 MONTHS OLD AND CLEARINGS 9 TO 21 WERE 2 MONTHS OLD. (SEE TABLE 2 FOR 1946 DATA.)

Clearing Number	Length Yds.	Width or Diam. Yds.	Aver. Depth In.	Area Sq. Yds.	Volume Cu. Yds.	Dynam. Sticks Used	Excav. per Stick
1	33.3	3.7	14.8	123.2	52.6	172	0.31
2	35.3	4.3	12.0	151.8	47.8	141	0.34
3	41.7	4.0	10.9	166.8	48.0	168	0.29
4	38.0	4.0	9.4	152.0	37.6	153	0.25
5	42.3	4.8	12.2	203.0	63.2	181	0.35
6	49.0	4.0	11.1	196.0	58.0	204	0.29
7	22.0	6.0	6.1	132.0	20.7	81	0.26
8	25.0	3.7	11.7	92.5	27.7	99	0.28
9	36.7	8.3	22.5	304.6	166.2	310	0.54
10	39.0	6.4	20.4	249.6	128.6	160	0.81
11	38.7	6.0	23.1	232.2	137.4	160	0.86
12	41.3	9.0	16.5	371.7	152.9	530	0.29
13	40.0	7.3	20.7	292.0	153.2	306	0.50
14		10.4	34.5	83.7	80.3	103	0.78
15		12.6	29.4	126.3	103.2	214	0.48
16	34.7	5.7	26.3	198.0	136.1	160	0.85
17	40.0	7.1	29.8	284.0	213.5	320	0.67
18	36.3	6.7	25.7	243.2	157.0	214	0.74
19		10.6	30.9	89.2	76.7	104	0.76
20		11.0	51.2	94.8	134.9	167	0.81
21	126.2	6.7	20.7	836.5	470.2	636	0.74
Total and Averages							
1–8					355.6	1,199	0.30
9–21					2,110.2	3,384	0.62
1-line 1941					872.3	1,116	0.79
2-line 1941					532.9	936	0.57
3-line 1941					152.9	530	0.29
Post-hole 1941					395.1	588	0.68

10B) that the necessary profile measurements cannot be accurately taken. The nearest to initial excavation figures secured were those taken in 1941 approximately two months after the blasting of Clearings Nos. 9 to 21. Table 1 lists excavation rates for these clearings ranging from 0.29 to 0.86 cubic yard per cartridge of dynamite and averaging 0.62 cubic yard. The 1940 clearings (Nos. 1 to 8), measured when a year and a half old, averaged 0.30 cubic yard per cartridge of dynamite. This indicates a considerable loss in volume between the second and 18th months after the blast, if it is assumed that initial excavation rates were at all comparable to those of 1941. There is no doubt that sedimentation is a decelerating process. Measurements of Clearings Nos. 9 to 21 are used for comparisons of blasting efficiency, but the fact that they were taken after two months of possibly rapid sedimentation should be borne in mind.

Regardless of substrate or water conditions at the time of blasting, the one-line charge removes more dirt per dynamite unit than the two-line charge, while the three-line charge removes the least of any (Table 1; Figure 5). Post-hole charges, especially over a hard substrate, approach one-line charges in blasting efficiency. Unless a very strong

wind is blowing, it might be expected that the wider the clearing, the more lifted debris will fall back into the excavation. This explains the low efficiency in the three-line charge: 0.29 cubic yard per cartridge of dynamite. It may as well be discarded at the outset as being uneconomical. The same would apply with more force to multiple-line charges of more rows. A five-row charge was attempted in Utah (Low, in Utah Coop. Wildf. Res. Unit., 1947) and the excavation received "a big portion of the dirt lifted" and attained a depth of only 1.7 feet. While the two-line charge may not be so efficient at the outset as the one-line charge, it has use possibilities which will be brought out later.

The advantage of blasting over hardpan is readily demonstrated and might be expected since more force is given the blast by the increased downward pressure. The 545-foot single-line charge excavated in Little Wall Lake (Scott and Dever, 1940) extended from where the hardpan was less than 2½ feet below the surface to where the peat was over 10 feet deep. And even though the dynamite load was increased in proportion to the depth to hardpan, measurements two years later showed a gradual reduction in cross-sectional area from 23.9 square feet over the hardpan to 16.1 square feet over the deep peat (Figure 1). The single-line 1940 excavations in the Oppedahl Tract showed average cross-sectional areas 18 months after blasting of 12.7 square feet over hardpan (everywhere over four feet below the surface, however) and 11.4 square feet over deep peat. The 1941 single-line excavations showed average cross-sectional areas two months after blasting of 37.3 square feet over hardpan and 32.3 square feet over deep peat. In the Utah experiments of 1947, all of which were over clay, the blasting efficiency was described as better the harder the clay (Low, in Utah Coop. Wildl. Res. Unit., 1947).

It is difficult to dissociate the effects of water-level conditions at the time of blasting from those attributable to charging methods and substrates, and particularly from the effects of water levels immediately subsequent to the blasting. The 1940 excavations were all done when water stood from four to six inches deep over the marsh (Plates 10B and 11A). The 1941 excavations were done under water-level conditions ranging from eight inches below the ground surface (Plate 10C) to six inches above it. Figure 9 indicates a generally lower blasting efficiency for the 1940 clearings. Table 1 shows that Clearing No. 18, where the ground was extremely dry, and Clearing No. 21, where it was extremely saturated, compare poorly in initial excavation with other single-line charges of 1941 where the water table was either at or slightly below the ground surface. The explanation probably lies in the extremes of lesser pressure when too dry and greater weight of soil when too wet. It is reasonably safe to assume that blasting efficiency in peat or muck is greatest when the water table is either at or less than four inches below the ground surface at the time of blasting. The 1940 blastings were over ground not entirely thawed out, and it was noted that "the partially frozen soil of part of the spots chosen seemed to lend power to the dynamite" (Low, Scott, and Dever, 1941). This should be accepted with caution, since on the

whole blasting efficiency was probably poor in these 1940 excavations (Plate 10B).

DURATION OF EXCAVATIONS

Initial excavation means little because it is not long maintained. The soupy condition of the site immediately after the blast implies at once a considerable loss of cross-sectional area in the process of stabilization. The rate of such loss should figure largely in any evaluation of the different blasting methods and of the technique in general.

Table 2 and Figure 9 show the rate of loss in volume in these experimental clearings. The volume losses in Clearings Nos. 1 to 8 (1940) in the five-year period 1941–1946 varied from 18 to 44 per cent (average 25 per cent), while for Clearings Nos. 9 to 21 (1941) the loss in volume varied from 28 to 79 per cent (average 45 per cent). This indicates a greater loss in the early years following the blasting and a general deceleration in the sedimentation process. The rate of volume loss was greatest in post-hole charges and least in two-line charges. In single-line charges, the rate of loss was small enough that the initial advantage in excavation rate per unit cost persisted after five years. The initial advantage in cost of post-hole charges over two-line charges, however, disappeared by the third year, and in five years the two-line charges surpassed in volume per initial cost the post-hole charges.

The rate of loss in average depth (Table 2; Figure 9) corresponded roughly with the rate of volume loss. Since loss of depth is to a large extent accomplished through erosion of the banks and slipping of the slopes (Plate 11B and 11D), there is frequently an increase in surface area to compensate for decreased depth, so that volume changes are minimized. Therefore the loss in average depth generally exceeds the loss in volume. During the same five-year period, the 1940 clearings lost from 8 to 44 per cent of their depth (average 35 per cent) and the 1941 clearings lost from 28 to 76 per cent of theirs (average 54 per cent). As in volume loss, the two-line charges showed the lowest rate of depth loss, while the post-hole charges showed the highest. From the standpoint of effectiveness of excavations, average depth means more than volume since it is the factor involved in revegetation of the opening.

EXPLANATION OF PLATE 10

PLATE 10. *A*. Post-hole shot (Clearing No. 20) in Dewey's Pasture, October 1941. Shows uniform density of bulrush-cat-tail marsh being opened up. *B*. Fresh excavation (Clearing No. 5) in the Oppedahl Tract, May 1940. Shoulders here represent probably maximum height attained in blasting. *C*. Fresh excavation in the Oppedahl Tract, October 1941, showing initial depth attained in 1941 when water table was under surface. *D*. Clearing No. 10 in Oppedahl Tract, October 1946, five years after blasting. Weeds in center mostly *Chenopodium rubrum*, an annual. Clearing will still be "open" in the spring. *E*. Clearing No. 11 in Oppedahl Tract, July 1947, 69 months after blasting. Bur-reed is encroaching from the sides, leaving only a scant opening down the center of the clearing. *F*. Clearing No. 6 in Oppedahl Tract, May 1942, two years after blasting. Marsh vegetation has taken over shoulders but has not yet invaded clearing. In 1947 this clearing was virtually obliterated by the same marsh growth.

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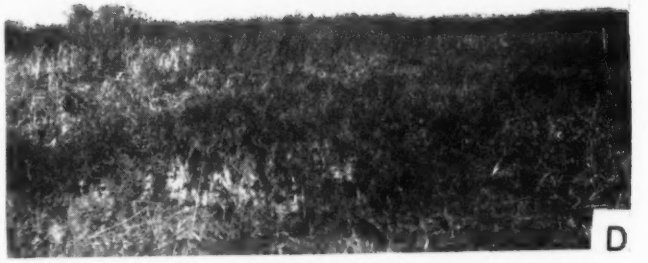

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TABLE 2.—LOSS OF VOLUME, DEPTH, AND AREA OVER 12 INCHES DEEP, OVER THE 5-YEAR PERIOD 1941–1946. FROM 18TH TO 78TH MONTHS IN CLEARINGS 1 TO 8; FROM 2ND TO 62ND MONTHS IN CLEARINGS 9 TO 21

Clearing Number	Volume			Aver. Depth			% Original Area Over 12 In. Deep		
	1941 Cu. Yds.	1946 Cu. Yds.	% Loss	1941 In.	1946 In.	% Loss	1941	1946	% Loss
1	52.6	29.7	*44*	14.8	7.8	*47*	61	0	*100*
2	47.8	34.0	*29*	12.0	7.4	*38*	51	0	*100*
3	48.0	32.3	*33*	10.9	6.2	*43*	48	0	*100*
4	37.6	29.7	*21*	9.4	7.3	*22*	35	0	*100*
5	63.2	52.0	*18*	12.2	7.8	*36*	52	19	*64*
6	58.0	40.8	*32*	11.1	6.2	*44*	48	0	*100*
7	20.7	16.1	*22*	6.1	5.6	*8*	0	0	*0*
8	27.7	23.1	*17*	11.7	8.3	*29*	50	16	*68*
9	166.2	108.5	*35*	22.5	13.4	*40*	78	70	*10*
10	128.6	54.9	*57*	20.4	6.9	*66*	64	18	*72*
11	137.4	77.0	*44*	23.1	10.8	*53*	78	57	*27*
12	152.9	84.4	*45*	16.5	8.3	*50*	50	12	*76*
13	153.2	98.3	*36*	20.7	11.5	*44*	71	71	*0*
14	80 3	17.1	*79*	34.5	8.4	*76*	70	1	*98*
15	103.2	35.7	*65*	29.4	8.7	*71*	70	18	*74*
16	136.1	61.9	*55*	26.3	12.2	*54*	79	54	*32*
17	213.5	154.2	*28*	29.8	19.9	*33*	82	67	*17*
18	157.0	112.6	*28*	25.7	18.4	*28*	77	60	*22*
19	76.7	38.8	*49*	30.9	12.3	*60*	61	39	*36*
20	134.9	56.6	*58*	51.2	20.1	*61*	78	67	*14*
21	470.2	248.1	*47*	20.7	8.9	*57*	76	38	*50*
Averages									
1–8	44.5	32.2	*25*	11.0	7.1	*35*	43	4	*79*
9–21	162.2	88.3	*45*	27.0	12.3	*54*	72	44	*40*
1-line 1941	243.1	110.5	*54*	22.6	9.7	*57*	74	42	*43*
2-line 1941	177.6	120.3	*32*	24.3	14.9	*39*	84	69	*18*
3-line 1941	152.9	84.4	*45*	16.5	8.3	*50*	50	12	*76*
Post-hole 1941	98.8	37.1	*62*	36.5	12.4	*66*	70	31	*56*

As mentioned above, area of excavation frequently increased with the age of the clearing. This is best illustrated in Clearings Nos. 10 and 19 (Figures 6 and 8). The largest increase in area over a five-year period was 26.6 per cent in Clearing No. 19. The average for the 1940 clearings was 11.5 per cent in-

EXPLANATION OF PLATE 11

PLATE 11. *A*. Fresh excavation in the Oppedahl Tract, May 1940, showing shallow depth attained when water table was above surface. *B*. Clearing No. 12 in Oppedahl Tract, May 1942, 8 months after blasting. This was a 3-line charge. *C*. Clearing No. 10 in Oppendahl Tract, May 1942, 8 months after blasting. Open water at left is where vegetation was buried by falling debris of blast. Shoulders are still very unstable. *D*. Clearing No. 12 in Oppendahl Tract, October 1946, five years after blasting. Weeds, mostly *Rumex maritimum* and *Chenopodium rubrum*, and large bur-reed completely cover the shallow bottom. Marginal areas flattened by falling debris when excavated are now covered with *Bidens cernua*.

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crease, that for the 1941 clearings was 10.0 per cent. Area in itself means as little as volume, however. On the other hand, percentage area over 12 inches deep is a most significant measurement, since it was observed that, in the Ruthven Area, depths less than 12 inches were quickly grown to vegetation, which reduced the value of the "clearing." Figure 9 shows loss rates in area over 12 inches deep. Again the two-line charge easily excelled any other charging method. In the 1940 clearings the loss in area over 12 inches deep over the five-year period varied from 64 to 100 per cent (average 79 per cent); in the 1941 clearings this loss varied from 0 to 98 per cent (average 40 per cent).

Losses in depth and volume result primarily through erosion of the sides. Especially important, therefore, are the water levels immediately subsequent to the blasting. Figure 9 shows clearly the marked superiority of the 1941 clearings over those of 1940, even when similar charging methods were employed under similar water and soil conditions. In comparing water-level histories of these two series of clearings one fact stands out in bold significance. The 1940 blasting was followed by drought and continual recession of the water table; the 1941 blasting was followed by heavy rainfall and almost immediate and complete inundation (Plates 11B and 11D) of the blasted sites. The indication is therefore that inundation of the excavations during the period of early stabilization preserved their volumes and depths, while exposure to air hastened loss of both. In other words erosion in this instance seemed more severe in air than in calm water. There is more evidence for this. Of the 1941 clearings, for instance, Nos. 17 and 18 are the two which retained most water through the years, both being often completely inundated. And it is precisely these two which showed by far the lowest loss rates in volume and depth (Table 2). The other extreme was Clearing No. 14, which was always the first of the clearings to go dry; it showed the greatest loss of both volume and depth over the five-year period. It is true that this was a post-hole clearing, in which loss rates are always high, but it still compared very poorly with Clearing No. 19 which was a similar charge over similar soil and which had almost identical initial volume, differing only in being deeper in the marsh. A possible explanation for this phenomenon of lesser sedimentation under water would lie in the fact that soils exposed to alternate drying and wetting fragment more quickly than soils continually wet or dry. This is especially true of mucks, which shrink greatly on drying, since their component clays and peats hold so much water by adsorption and absorption respectively. It follows then that a well-fragmented soil would sooner erode than one of more solid structure.

Probably of equal importance in determining duration of excavations would be the composition and structure of the soil in the banks and sides. Where the hardpan is not penetrated by the blast, as in all Oppedahl Tract excavations, the soil of the banks and sides will be of the same composition as the top soils of the marsh though the structure was altered by the blast. When the hardpan itself is moved by the blast, as in all the Dewey's Pasture excavations, the banks and sides differ from the un-

disturbed marsh soils in both composition and structure. Where adhesiveness between soil particles (occurring in many clays due to method of deposition) does not exist, the angle of repose in a free slope will be proportional to the size of the soil particles, *i.e.*, the coarser gravels and sands will assume a

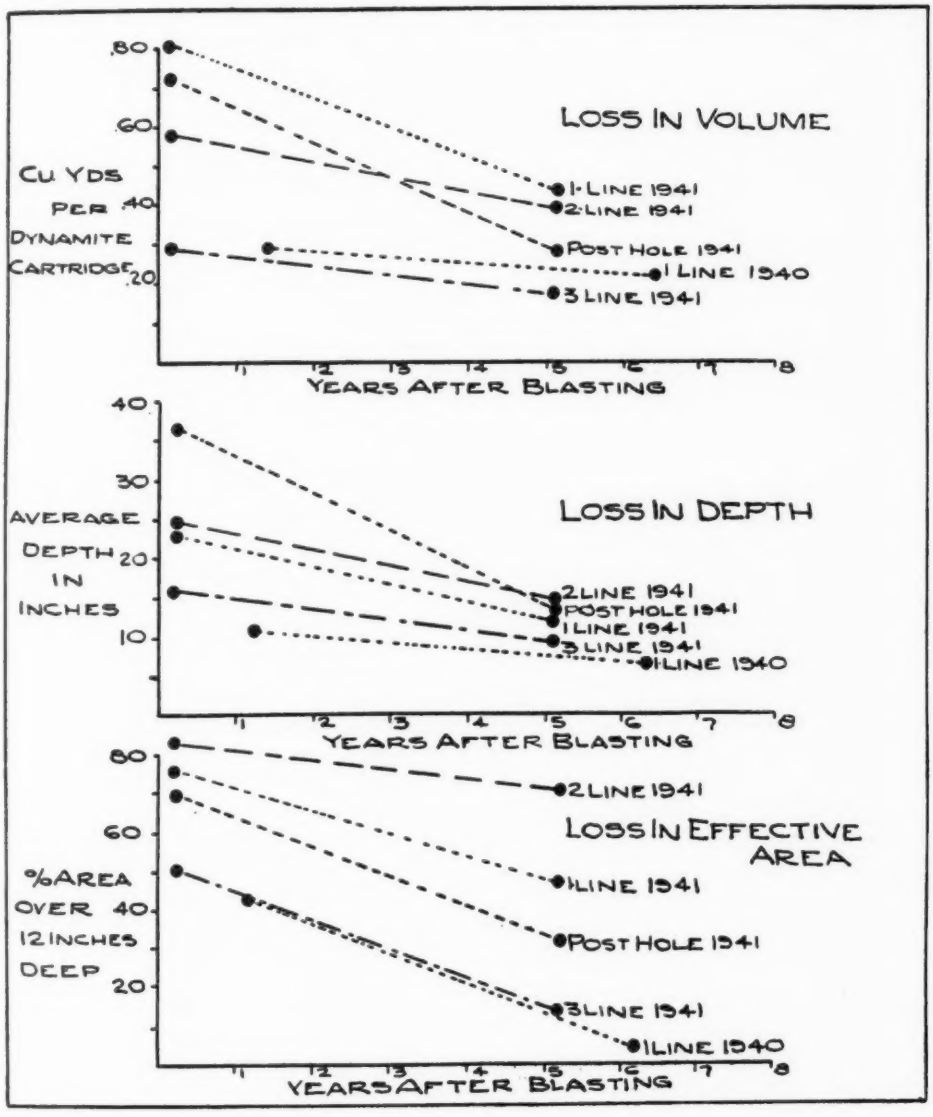

FIG. 9.—Average five-year losses in volume, depth, and effective area in clearings variously blasted. These lines do not represent actual progress of sedimentation, but only losses over entire period.

greater slope under stabilization than the fine sands and silts. Since blasting obviously loosens the soils of the excavation, it should be indicated therefore that steeper slopes and more permanent banks will result when excavated soils are coarse. Herein lies the most plausible explanation for the steeper slopes and more satisfactory banks in the Dewey's Pasture clearings. The implication is that it is most desirable not only to blast over a coarse hardpan but to employ charges which will materially penetrate this hardpan. This principle was well demonstrated in the experimental dynamiting. Excavations made in 1941 showed not only a greater slope in sandy clay, but a lesser loss of slope over a five-year period (Table 3). In the Little Wall Lake excavation, two years after the blasting, the slope over the clay substrate was three times that over the deep peat (Table 3; Figure 1). In the 1941 clearings, the best, highest, and most firm banks were those thrown up by a blast in sandy clay. Clearing No. 16, where gravel and boulders were thrown on the bank, had the most satisfactory banks of any clearing (Plate 12A). The four clearings blasted over very coarse clay (Nos. 16, 17, 18, and 20) have given

TABLE 3.—SLOPE OF EXCAVATIONS AS RELATED TO TYPE OF SOIL SUBSTRATE, AND AMOUNT OF SUBSIDENCE OF SLOPES IN A FIVE YEAR PERIOD

Clearing Number	Degree of Slope		% Loss in Slope	
	1941	1946	18–78 Mos.	2–62 Mos.
1	21°10′	10°28′	*51*	
2	13 20	6 33	*48*	
3	14 29	7 03	*50*	
4	14 29	9 21	*35*	
5	12 23	8 12	*30*	
6	14 29	6 42	*54*	
7	5 45	4 54	*15*	
8	15 51	12 45	*19*	
9	16 53	12 30		*26*
10	19 44	6 24		*68*
11	20 12	10 15		*50*
12	12 02	6 24		*48*
13	16 57	9 37		*41*
14	17 51	5 45		*70*
15	11 17	3 44		*66*
16	25 07	11 29		*54*
17	18 48	18 28		*2*
18	23 35	16 50		*29*
19	18 35	6 07		*67*
20	29 07	12 07		*58*
21	17 28	7 29		*57*
Average				
Peat 1940	13 12	8 08	*38*	
Peat 1941	15 23	6 17		*60*
Clay 1941	17 17	8 18		*52*
Sand 1941	23 02	13 00		*43*
Little Wall Lake 1939				
Clay	28 40			
Peat	8 18			

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definitely the best results from the standpoint of effective duration. In three of these the blasting opened up springs near the bottom of the excavation, so that the holes filled from the bottom rather than from seepage through the sides. The spring struck in Clearing No. 17 at first bubbled up 18 inches across and one foot high; it delivered very turbid, yellowish-gray water containing gravel, shells, and even a piece of petrified wood. The slope of the sides in a marsh excavation is quite important. Detailed plant ecological studies made in the Ruthven Area have demonstrated the significance of bottom gradient to marsh cover, and in these clearings it has been shown that the more gradual the slope of the sides the quicker will be the revegetation and loss of effectiveness in the clearing. Sharp sides and high banks are desirable even apart from their possible direct use to wildlife.

Two other sedimentation factors may be mentioned. First, rate of sedimentation in similar soils increases with degree of slope in the sides. This obvious fact explains the high rate of volume and depth loss in post-hole charges as compared with line-charges. This also suggests that the attainment of great initial depth (if hardpan is not penetrated) is of no consequence since it is accomplished at the cost of greater sedimentation rate. Secondly, rate of sedimentation increases with the ratio of perimeter to area. This, in turn, explains why sedimentation rate is less in multiple-line charges than in single-line charges which produce narrower ditches.

THE FLORA OF THE CLEARINGS

Blasting leaves a truly denuded area in the marsh, and it is not surprising that the vegetational development should be a recapitulation of the plant succession occurring locally under corresponding water-level conditions. This plant invasion is important because it may either reduce or enhance the value of the clearings. In 1941 vegetation transects were taken of the Little Wall Lake excavation, then two years old, and of Clearings Nos. 1 to 8 then 18 months old in the Oppedahl Tract. Figures 10 and 11 show the composite findings. It is seen (Figure 10) that the dominant plants (lake sedge, river grass, and cat-tail) in the Oppedahl Tract were beginning to take over the shoulders of the excavation. The following summer (1942) the invasion was almost complete (Plate 10F), with river grass in the lead, and by 1947 the vegetation of the shoulders was essentially

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EXPLANATION OF PLATE 12

PLATE 12. *A*. Clearing No. 16 in Dewey's Pasture, October 1946, five years after blasting. Hard shoulders, steep slopes, and sandy substrate have prevented marsh vegetation from entering the clearing, which remains completely "open." *B*. Clearing No. 15 in Oppedahl Tract, July 1947, 69 months after blasting. This post-hole clearing is still open but cat-tail is invading rapidly from the left, and lake sedge is advancing in from the right. *C*. Clearing No. 21 in Dewey's Pasture, October 1946, five years after blasting. *D*, Same as *C*, but photographed at further range on the same day. Like most clearings at lower elevations in the marsh, this cross-shaped opening has remained free of emergent vegetation. Note growth of pond weed (*Potamogeton foliosus*) in the water of the excavation while the pond bottom surrounding it is almost dry.

like that of the surrounding marsh and was moving into the excavations proper. The characteristic group of composite and labiaceous plants and cut-grass (*Leersia oryzoides*) which occupied the newly-formed shoulders was disappear-

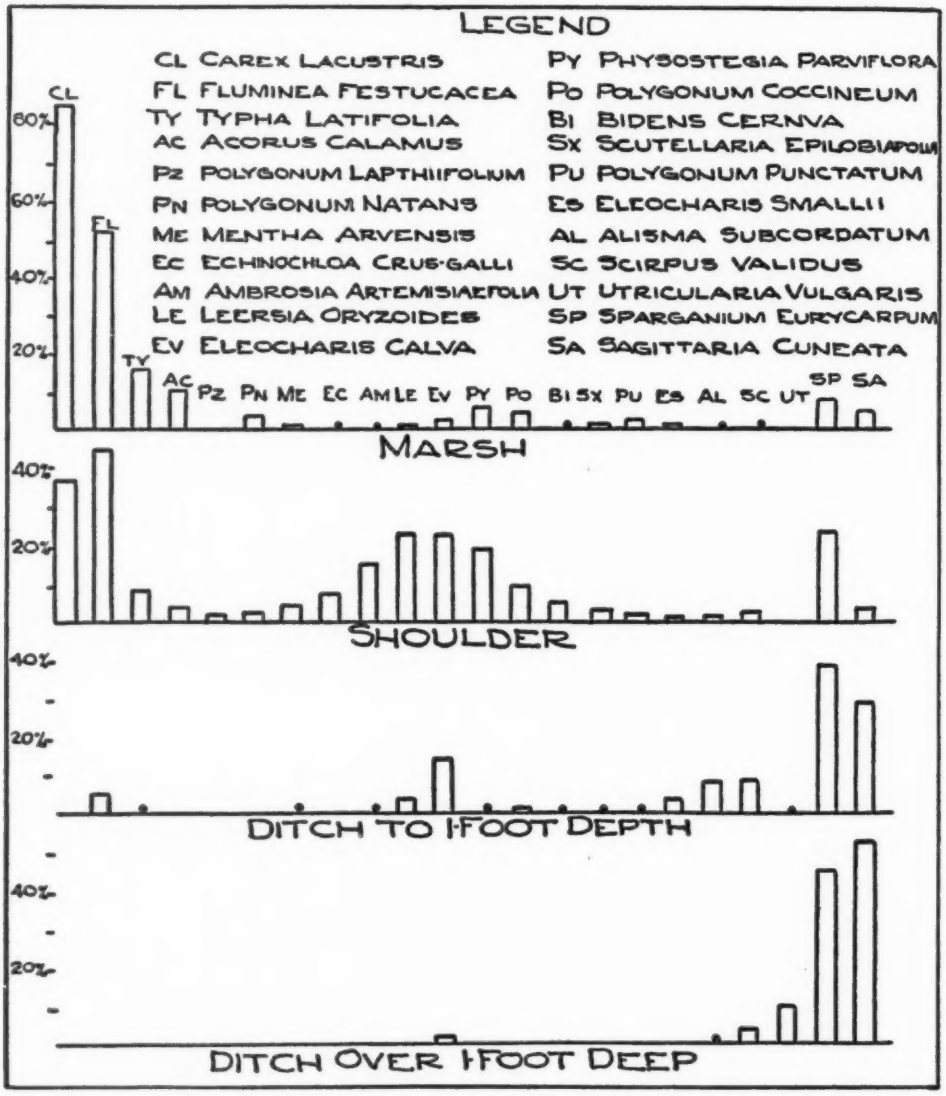

FIG. 10.—Vegetation of the blasted sites, Clearings Nos. 1 to 8, Oppedahl Tract, October 1941, 16 months after blasting. Expressed in percentage of occurrence in square-foot samples of 26 transects each a foot wide and extending at least 20 feet into the undisturbed marsh on either side of the clearings.

ing by 1942 and was gone by 1946. High water levels subsequent to 1941 hastened this process. The ditches proper were dominated in 1941 by great bur-reed, arrowhead (*Sagittaria cuneata*), water-plantain (*Alisma subcordatum*), soft-stemmed bulrush (*Scirpus validus*) and bladderwort (*Utricu-*

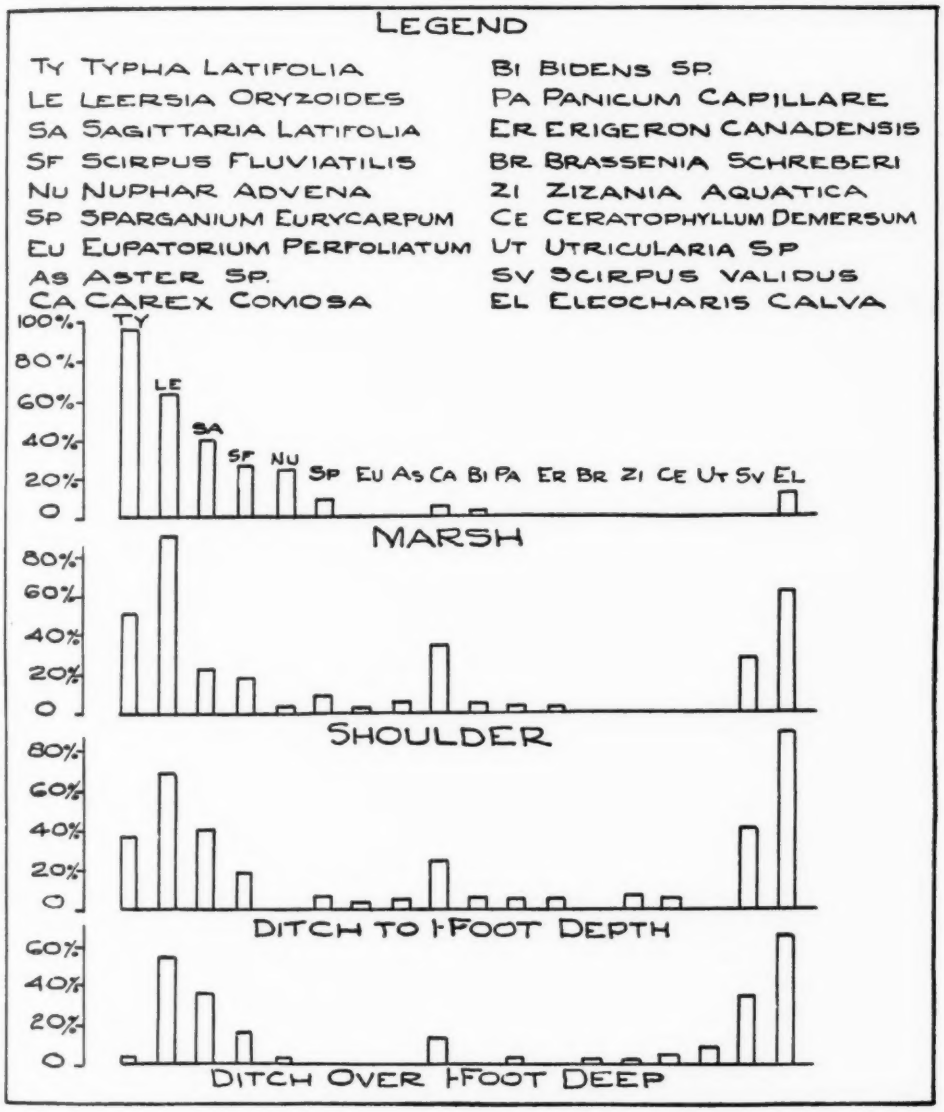

FIG. 11.—Vegetation of the blasted site at Little Wall Lake, July 1941, two years after blasting. Expressed in percentage of occurrence in square-foot samples of 8 transects each a foot wide and extending at least 20 feet into the undisturbed marsh on either side.

laria vulgaris). In 1947, bur-reed and arrowhead were still the dominant emergents, while foliose pondweed (*Potamogeton foliosus*), bladderworts, watermilfoil (*Myriophyllum spicatum*), duckweeds (*Lemna trisulca, Spirodela polyrhiza*), and riccias (*Ricciocarpus natans, Riccia fluitans*) choked all "open" water. The plants of the blasted sites furnished more desirable duck foods than the undisturbed marsh. And those plants which took over the excavations, even seven years after the blasting, were species which appear above water late in the growing season and which leave little stubble over winter. This meant that much "open" water occurred in the ditches at the time of nest establishment for most marsh-nesting birds, even though a heavy growth hid the water by mid-summer (Plate 10E).

The excavation at Little Wall Lake was in deeper portions of marsh than those above described in the Oppedahl Tract. In two years, the marsh dominants (cat-tail, rice cut-grass, arrowhead, and river bulrush) had invaded the shoulders more completely (Figure 11) and had advanced into the excavation so that the vegetation of the shoulders differed little from that of the ditch to a depth of one foot. Even the deepest parts of the ditch resembled the marsh proper in flora, differing only by lesser amounts of cat-tail, river bulrush, and spatterdock (*Nuphar advena*), and by greater amounts of spike-rush (*Eleocharis calva*), soft-stemmed bulrush, coontail (*Ceratophyllum demersum*) and bladderwort. A fact was here demonstrated which appears to be of wide application. The plant invasion of the blasted sites advanced from two opposite directions. From the undisturbed marsh, the dominant emergents advanced toward the excavation by extension of underground parts, eventually displacing annuals and taking over the banks, then proceeding into the excavation (Plate 12B). Meanwhile another group of plants, bur-reed, waterplantain, arrowhead, bladder wort, coontail, and others, established itself in the excavation by seed germination or by chance introduction of winter-buds or turions. This group met the invaders from the marsh usually at the waterline under the banks.

Water tables, almost exclusively, determine and select those plant species which are to invade by underground parts or by germination. Table 4 lists the plant communities establishing themselves on the Iowa experimental clearings. Very few of the species involved would have occurred had the water levels been stable. Indeed, the groups are absolutely typical of the fluctuating water flora found in marshes of the region in their higher portions (shoulders) and in their lower portions (excavations).

By and large, the plants were undesirable from the standpoint of maintenance of either shoulder or excavation. It is therefore suggested that the shoulders be seeded after the blasting and that the vegetation in the ditches be kept under control with a good herbicide. Although the shoulders could probably produce fine crops of millet (*Echinochloa*), wild rice (*Zizania*), and smartweeds (*Polygonum*), such annual duck foods would not anchor the soil of the banks any more effectively than the species which establish themselves naturally. A sod-former which can thrive either submerged or emersed

would be ideal. Observations in Iowa indicate that canary-grass (*Phalaris arundinacea*) may suit the purpose.

recalled that water levels in themselves are the primary determinants of interspersion in a marsh. Thus the years

TABLE 4.—DOMINANT PLANTS ON THE EXPERIMENTAL CLEARINGS IN IOWA, PRIOR TO INVASION BY THE VEGETATION OF THE SURROUNDING MARSH

Height	A. SHOULDERS Dominant Plants
High	Lesser Ragweed (*Ambrosia artemisiaefolia*) Wild Millet (*Echinochloa crus-galli*) False Dragonhead (*Physostegia parviflora*) Wild Mint (*Mentha arvensis*)
Medium	Rice Cut-grass (*Leersia oryzoides*) River Grass (*Fluminea festucacea*) Nodding Bur Marigold (*Bidens cernua*) Marsh Skullcap (*Scutellaria epilobiafolia*)
Low	Creeping Spike-rush (*Eleocharis calva*) Large Bur-reed (*Sparganium eurycarpum*) Water Smartweed (*Polygonum coccineum*)
	B. EXCAVATIONS
Type	Dominant Plants
Shallow-water	Golden Dock (*Rumex maritimus* var. *fueginus*) Red Goosefoot (*Chenopodium rubrum*) Nodding Bur Marigold (*Bidens cernua*) Cyperus (*Cyperus* sp.)
Medium-water	Giant Bur-reed (*Sparganium eurycarpum*) Arrowhead (*Sagittaria cuneata*) Water Plantain (*Alisma subcordatum*)
Deep-water	Foliose Pondweed (*Potamogeton foliosus*) Water Milfoil (*Myriophyllum spicatum*) Bladderwort (*Utricularia vulgaris*) Coontail (*Ceratophyllum demersum*) Ivy-leaved Duckweed (*Lemna trisulca*) Greater Duckweed (*Spirodela polyrhiza*) Slender Riccia (*Riccia fluitans*)

ANIMAL USE OF THE CLEARINGS

Animal use of the dynamited clearings was conditioned by so many extraneous factors that accurate measurement of responses to the better interspersion of cover and water was most difficult. The fundamental difficulty lay in the inadequacy of water-level control on experimental and check areas. The significance of this is evident when it is

1942 to 1946 were years of excessive rainfall, which destroyed several contemplated check areas by transforming them from vegetation-choked marshes to open-water lakes (*e.g.*, Little Wall Lake and some ponds in Dewey's Pasture). But even had the water levels and interspersion been under control, other difficulties would have been encountered. An important factor conditioning the effect of interspersion on

nesting densities, for instance, is the migratory nature of the birds in question. In a bird population which is not only transitory but hunted on and off the experimental and check areas, it would be hazardous to attribute fluctuations in nesting densities exclusively to local environmental changes. The redhead (*Nyroca americana*) was fairly common in the Ruthven Area from 1938 to 1941, but was reduced to a few scattered breeding pairs from 1942 to 1947. The marsh covers could at all times have supported a heavier nesting density than was ever found. This example is especially meaningful since it had been hoped to use the redhead as a key indicator to waterfowl responses to interspersion. The muskrat (*Ondatra zibethicus*) is another animal which was expected to respond to changes in interspersion, but its numbers from year to year may fluctuate quite regardless of habitat conditions. In the Ruthven Area, muskrats became very abundant in 1941 and 1942, but by 1946 they were scarce everywhere. Because of many such eventualities, responses observed were mainly inconclusive.

BLUE-WINGED TEAL

The blue-winged teal (*Querquedula discors*) is easily the predominant nesting duck of the areas under study, for which reason it is considered separately In the spring of 1940,[2] the newly-blasted holes (Nos. 1 to 8) in the Oppedahl Tract were in constant use by blue-winged teal. During the nesting season pairs were seen on the banks or on the waters of all clearings except No. 7, which had the least shoulders of any. At four of the clearings, two pairs of teal were observed at one time. Dropped eggs and feathers were found at several clearings. One nest was located 60 yards from Clearing No. 3. These clearings were fairly close to one another and the same pair of ducks or the same territorial drake may have frequented more than one. However, the consistency of observations is reasonable evidence that at least five pairs used the clearings as bases for nesting operations. Throughout the season of observation (May to August) the water-table was receding. Even as early as mid-June the birds were apparently shifting from the border clearings (Nos. 1, 2, and 3) to those clearings (Nos. 4, 5, and 6) which were at lower elevations in the marsh and held water longer. There is no record of teal seen at the clearings after June 18, by which time the marsh was dry and the excavations nearly so. Water levels being as low as this, it may be assumed that many of the teal attempted nesting in the marsh (*e.g.*, the nest near Clearing No. 3). If broods were hatched, the ducklings had to make their way through hundreds of yards of exceedingly rank vegetation to reach the nearest remaining water, the channel north of the island. One surmise only is indicated: a poor reproductive success.

In the spring of 1942, the tract contained 15 clearings, seven new ones having been blasted in the fall of 1941. The water levels were high throughout the nesting season, the marsh itself being under 10 to 21 inches of water. During migration, as many as 54 pairs of blue-winged teal were observed at

[2] In this section all remarks on the 1940 responses are based on records given by Low, Scott, and Dever (1941). The interpretations, however, are the author's.

the clearings on one day (April 21), all but two pairs on the *new* clearings. Clearing No. 11 alone had 18 pairs lined up abreast on its high and broad banks. During the ensuing nesting season it was estimated that three pairs used the old clearings while four pairs operated out of the new clearings. An intensive nest survey yielded only one nest in the marsh, and it was flooded out by a small rise in water level in late May.

In 1947 only two pairs of teal were observed repeatedly, one at Clearings Nos. 1 and 2, and the other on Clearing No. 6. The waters again were high, four to 12 inches over the marsh, and an intensive survey revealed no nests at all in the marsh. In the Ruthven Area generally, blue-winged teal nesting numbers were only slightly lower than in 1942.

The new clearings (Nos. 16 to 21) in Dewey's Pasture were likewise popular with migrating blue-winged teal in the spring of 1942. On April 27, 15 pairs were counted on them. During the nesting season only Clearing No. 16 held an apparently resident pair. All other clearings were completely inundated and the ponded areas easily accommodated the 50-odd pairs nesting in the 300 acres of upland bluegrass. The same situation prevailed in the spring of 1947, when the pair using Clearing No. 16 nested in the bluegrass on a nearby slope. This offered the best example in this study of a dynamited clearing rendering the surrounding upland more useful to nesting teal, for no other open water existed within 300 yards.

The use of dynamited clearings in the fall was observed only in 1941. Observations were made until mid-December that year. The 18-month old clearings (Nos. 1 to 8) were dry until mid-October and were used only sporadically after that date by teal. No teal were personally observed on the freshly-blasted clearings (Nos. 9 to 21). It was reported, however, that when teal were flushed out of the channel north of the island in the Oppedahl Tract they would settle in one clearing after another and in this manner offered the hunter good sport. On opening day (October 16) 13 hunters were on the tract and shot teal and mallards mostly. Most of the birds were obtained from the open channel. Three men were hunting over decoys on Clearing No. 4; they had shot three mallards and one blue-winged teal and had shot at but missed a baldpate. Properly used, these dynamited clearings could certainly be expected to offer good duck hunting. Their greatest value would probably come after the first blast of opening day, when they would serve to disperse ducks, hunters, and sport.

Summarizing these observations, then, it is clear that the dynamited clearings in sedge marshes were especially attractive to blue-winged teal on the spring migration and when the excavations were new. The naked shoulders were apparently the main attraction, as they constituted ideal resting sites, close as they were to the open water of the excavation (Plates 11B and 11D). Nesting teal were also attracted to the new clearings, using them as resting and waiting sites. Drakes frequented the clearings regularly during the nesting season; they probably established territories on the ditches. Nevertheless, as inducements to nest *in*

a sedge marsh, the clearings performed a service of dubious value. In normal years such marshes dry up too early for the welfare of the broods, while the least rise in water level threatens the nest, for these teal are normally upland-nesting ducks. It is also indicated that as the clearings aged and the shoulders assumed the character of the surrounding marsh, they lost their attractiveness to both migrating and nesting teal. It is fairly certain that if these dynamited clearings are to continue their service to blue-winged teal, their banks must remain high and dry and their contained waters must remain free of emergent vegetation. And probably the greatest service they can render these teal is the making of adjacent pastures more attractive as nesting cover. But even this must be qualified, for if there is no guarantee or reasonable expectancy of continued presence of water nearby the ducks will only be invited to failure in nesting. Finally, under proper management and use, these clearings could materially improve duck-hunting.

OTHER PUDDLE DUCKS

In the nesting season of 1940 the new clearings were used sparingly by mallards (*Anas platyrhynchos*), with one nest located 50 yards from Clearing No. 4. Single observations were also made of one pair of pintail (*Dafila acuta*) and one of shoveller (*Spatula clypeata*).

In the spring of 1942 the only observation made at the old clearings (Nos. 1 to 8) in the Oppedahl Tract was of a drake shoveller on May 26 at Clearing No. 2. On the other hand, the new clearings (Nos. 9 to 15) were used by many migrating puddle ducks, chiefly mallards and shovellers. On one day, April 21, 13 pairs of shovellers were counted at the new clearings. During the nesting season, it was estimated that regular use was made of the new clearings by three mallard drakes and two shoveller drakes. The nesting survey, however, yielded only two mallard nests and none of the shoveller in the marsh. One nest was 47 yards from Clearing No. 13, the other 70 yards from Clearing No. 8. Both were eventually flooded out by a rise in the water level.

Only a few mallards were observed on the clearings in the spring of 1947. Two mallard nests were found in that portion of the marsh where no blasting had been done.

The new clearings (Nos. 16 to 21) in Dewey's Pasture were visited by a variety of ducks during the 1942 spring migration, and here also mallards and shovellers predominated after the blue-winged teal. Occasional gadwall (*Chaulelasmus streperus*) and baldpate (*Mareca americana*) were observed. During the nesting season, a few mallard and shoveller drakes had apparent territories at the clearings. In 1947 no other puddle ducks than blue-winged teal were observed at the clearings during the nesting season.

The concluding remarks made for the blue-winged teal applied equally to mallard and shoveller, though both were much fewer in numbers on the areas. Mallards nested even more frequently within the marshes, however. But every single mallard nest found over water (except for nests on large muskrat houses) in 1942 and 1947 was eventually destroyed by rising waters. No

shoveller or pintail nest was ever found anywhere but on dry land. Migrational and hunting use of the new clearings by these puddle ducks paralleled such use by blue-winged teal. It was noticed, however, that although gadwall, baldpate, wood ducks (*Aix sponsa*), and green-winged teal (*Nettion carolinensis*) occurred frequently on the open channel in the Oppedahl Tract, only an occasional green-winged teal and wood duck visited the clearings. Migrating gadwall and baldpates did, however, stop at the deep and wide-open clearing (No. 21) in a large pond in Dewey's Pasture.

DIVING DUCKS

Use of the dynamited clearings by diving ducks was very limited. Redheads visited or used those clearings only which were located in bulrush or cat-tail cover (Nos. 6, 10, 17, 18, 20, and 21). In the spring of 1942 and 1947, flocks of redheads, canvasbacks (*Nyroca valisineria*), ruddy ducks (*Erismatura jamaicensis*), lesser scaups (*Nyroca affinis*), and ring-necked ducks (*Nyroca collaris*) were continuously observed on the open channel in the Oppedahl Tract during migration time, but none was ever seen at the nearby clearings. In the 1947 nesting season at least three pairs of redhead and six of ruddy stayed about the natural clearings in this marsh, but only one redhead was seen to visit a dynamited clearing and this was No. 10 which was almost continuous with the large southern natural clearing where cat-tail abounded. Clearings Nos. 17 to 21 in Dewey's Pasture are all in bulrush and cat-tail cover and were expected to be more often used by redheads and ruddies. Two circumstances prevailing in 1942 and 1947 made observations of such responses negligible: (1) high water-levels opened up the centers of the ponds and inundated the clearings to the point where they were lost to view in the waters, (2) redheads and ruddies were scarce in the area. In 1947 Clearing No. 18 was the center of a waiting site used by a redhead drake whose hen nested in the bulrushes 40 yards away, but there was as much open water out of the excavation as in.

It is conceivable that a large dynamited clearing in the deeper parts of a marsh, such as Clearing No. 21 (Plates 12C and 12D), might be of great service to diving duck broods in summers of low water levels, but this service was not observed in these studies. As a matter of fact, this would probably be the greatest improvement to duck habitat furnished by dynamited clearings. In the summer of 1947 pied-billed grebe (*Podilymbus podiceps*) and coot (*Fulica americana*) broods were seen frequently on Clearing No. 21, but since no diving ducks nested anywhere near the pond, none of their broods was observed.

COOTS

In marked contrast to the situation with reference to puddle ducks, coots and rails utilized the older clearings more than the new ones. In 1940 none was reported seen about the freshly-blasted clearings. In 1942 several observations of coots were made at the old clearings and only a few at the new clearings. There is very little indication, however, that the dynamited clearings induced coots to nest farther away from the natural openings in the Oppedahl

Tract marsh. At all times they used only those clearings in the bulrush and cat-tail cover. During the 1947 breeding season, as many as 25 coots were counted at one time on the natural clearings at the southern end of the marsh. Some of the nearby clearings (Nos. 10, 11, and 13) were occasionally visited. Clearings Nos. 12 and 15 were also surrounded by natural clearings that year and were, consequently, frequented by coots. It was obvious, however, that the topography of the marsh (Figure 3) had more to do with the distribution of coot nests than the artificial clearings. In both 1942 and 1947 coot nests were located only in the deeper parts of the marsh and therefore where the dominant vegetation was cat-tail, bur-reed, and bulrush. The 10-inch depression contour (Plate 10C) delimited their distribution, regardless of clearings. Clearings Nos. 10, 12, and 13 fell within this area and probably only because of this coot nests were found in their proximity. The five nests found in 1942 were situated over 15 to 19 inches (average 18.0) of water; the nine nests found in 1947, though in the same general area, were over water five to nine inches (average 7.9) or less than half as deep. The indication is therefore that neither depth of water nor artificial interspersion, in themselves, determined nest locations in the Oppedahl Tract. The critical factor was type and density of cover, as established by the topography of the marsh bottom.

In times of migration, clearings saw little use by coots, for at this time coots are in large flocks and visit larger and deeper waters than could be provided normally by clearings of this type.

In Dewey's Pasture, all the clearings but No. 16, which was in solid lake sedge, were visited continually by coots during the nesting season. Since the clearings were surrounded by natural open waters, their actual service to coots was not ascertained. A large, deep clearing, like No. 21, may attract migrating coots.

RAILS

Three species of rails nested in the Ruthven Area experimental marshes: king rail (*Rallus elegans*), Virginia rail (*Rallus limicola*), and sora (*Porzana carolina*). The latter two only were observed at the clearings, and their responses to the artificially created interspersion were approximately the same. Like coots, the rails were not seen about the clearings until the banks were well vegetated. In 1940 no rails were reported about the clearings. In 1942 several observations were made about the old clearings and none at the new ones. In 1947 many Virginia rails and soras were seen about the clearings in the Oppedahl Tract, for by this time the shoulders offered good cover and even the ditches proper were partly vegetated. In 1942 and 1947 nests of both sora and Virginia rail were spotted on a map of the Oppedahl Tract (Figure 3). The distribution indicates no correlation between nest locations and clearing locations. It was found that the rails preferred the sedge-cat-tail ecotone for nesting cover; nests were found in neither solid sedge nor solid cat-tail. Those clearings located in this ecotone (Nos. 3, 4, 5, 6, 12 and 15) are the ones at which rails were most frequently seen during the nesting seasons of both 1942 and 1947. The sedge-cat-tail ecotone by 1947 extended eastward across the marsh into the region where no clearings were made, and rail nests occurred here

as well. There is then no indication that the clearings affected the distribution of nesting rails.

Unlike coots, rails in migration were very much scattered throughout the marshes. They appeared singly or in pairs at any of the clearings where cover existed to the water's edge.

NON-GAME BIRDS

What influences the dynamited clearings had on the distribution of non-game bird nests is not too well indicated from these studies. Although nests of prairie marsh-wrens (*Telmatodytes palustris dissaeptus*), red-winged blackbirds (*Agelaius phoeniceus*), and yellow-headed blackbirds (*Xanthocephalus xanthocephalus*) were found close to the clearings, they occurred in the same general numbers away from the clearings. There is a strong likelihood that marsh-border birds like the swamp sparrow (*Melospiza georgiana*) and the Maryland yellowthroat (*Geothlypis trichas trichas*) could be induced to nest on the raised shoulders about the clearings. Both species were repeatedly observed about these clearings during the nesting season, often at great distances (*e.g.*, Clearing No. 4, 150 yards) from the shore.

During both migration and nesting time, birds of the heron group were frequently observed at the clearings. The American bittern (*Botaurus lentiginosus*) was the most common visitor. It was clear that these large waders came to the excavations for food. Their visits increased as the water in the ditches dried up and prey organisms (frogs, minnows, crayfish, etc.) became more concentrated.

Several bird species were observed at the clearings only in migration. In the fall of 1941, when Clearings Nos. 9 to 21 were bare mud and water, large numbers of Wilson's snipe (*Capella delicata*), American pipits (*Anthus spinoletta*) and rusty blackbirds (*Euphagus carolinus*) foraged about them. As many as 28 snipe were put up on the mud flat at Clearing No. 15, on October 14. Other shore birds were infrequently observed at the clearings that fall. The older clearings (Nos. 1 to 8) whose banks were grown to annual weeds mainly, were most attractive to a host of small birds. The more consistently observed were, in order of both numbers and frequency, swamp sparrows, short-billed marsh wrens (*Cistothorus stellaris*), Maryland yellowthroats, and Leconte sparrows (*Passerherbulus caudacutus*). Goldfinches (*Spinus tristis*) and song sparrows (*Melospiza melodia*) were accidental visitors. Neither in the spring of 1942 nor of 1947 were small migrating birds observed in so large numbers as occurred in the fall of 1941.

MAMMALS

The muskrat, of course, was the mammal to use the dynamited clearings most frequently and consistently. Mink (*Mustela vison*) tracks, scats, and other sign occurred in time at several of the clearings. Clearing No. 9 was taken over completely by a mink in the fall of 1946, with a den on one bank and burrows, scats, prey, etc. all about the shoulders of the clearing. In the spring of 1947, the clearing was still in the possession of a mink. Other mammals observed at clearings included raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*) (Low, Scott, and Dever, 1941), ground squirrel (*Citellus tridecemlineatus*), meadow mice (*Microtus pennsylvanicus*), and long-tailed shrews (*Sorex*

cinereus haydeni). Raccoon tracks were observed fairly commonly in the drying excavations. One long-tailed shrew was trapped in the ditch at Little Wall Lake in 1941, and one was seen alive in one of the Oppedahl Tract clearings in 1942.

A sedge marsh such as the Oppedahl Tract is not an adequate muskrat habitat from the standpoint of either water or food. While the dynamited clearings improved the water requirements of the habitat, they did not materially improve the food production of the marsh. Sedges (*Carex* spp.) are not generally preferred food for muskrats, while cat-tail and bulrushes definitely are. It was not surprising then to find those clearings surrounded by either bulrush or cat-tail to be the ones most used by muskrats. That the clearings were attractive to muskrats was evident by the amount of sign observed as well as the frequent observations of the animals themselves.

All the eight ditches blasted in the spring of 1940 had muskrat sign by July. One had a house built on the bank (No. 6) and two (Nos. 5 and 8) had bank burrows. A year later, in the fall of 1941, all but Clearings Nos. 1, 4, and 8 had signs of rat activity. Clearing No. 3 had a house built on the bank. The following spring, in 1942, or two years after the blasting, there were no signs of activity at Clearings Nos. 1, 3, 6, and 8. Houses were built on the banks of Clearings Nos. 2 and 4. Thus within two years, six of the eight clearings were actually occupied by muskrats, four as evidenced by houses on the banks, and two as evidenced by burrows. By 1946 there were no signs of additional houses having been built on the clearings, but general muskrat populations were low then.

The clearings in Dewey's Pasture, except for No. 16, were in the bulrush-cat-tail cover in the centers of the ponds. They were located in good habitat for muskrat, and except for two houses built directly on the clearings it would be difficult to demonstrate any precise response of the muskrats to the dynamited clearings. One pond of four acres had, in 1941 and 1942, an abundance of bulrushes but no open water. No sign of muskrat was found in this pond at that time. In 1946, the remains of no less than 34 houses were found. Of this number, seven were judged to have been built in the fall of 1942, 13 in 1943, 11 in 1944, and three in 1945. None was of 1946. This pond had been opened up in the fall of 1941 with two dynamited ditches, Nos. 17 and 18. There is scarcely any doubt that these deep holes influenced at least to some extent this population of muskrats. The local trapper who secured the skins was most enthusiastic in his praises of these excavations, which he claimed were responsible for the large density of muskrats following 1941.

So likely are the possibilities of improving muskrat habitat with dynamited holes, that the technique has been attempted on a fairly large scale in various parts of the United States. Although no special study of this phase of marsh improvement was made in Iowa, it can logically be assumed that beneficial results obtained in other localities were similarly obtained here.

COLD-BLOODED VERTEBRATES

Except for an occasional garter snake (*Thamnophis* sp.), the only reptiles observed in the clearings were some snap-

ping turtles (*Chelydra serpentina*) and painted turtles (*Chrysemys picta*). The mud bottoms were attractive to the former and the shoulders were particularly attractive to the latter. Leopard frogs (*Rana pipiens*) were exceedingly abundant in all the clearings in Ruthven as well as in the Little Wall Lake excavation. The mud of the drying excavations in late summer was frequently a living mass of these frogs. The swamp cricket-frog (*Pseudacris triseriata*) was seen only once. Small, unidentified minnows were left stranded in the drying excavations in the late summer of 1941.

INVERTEBRATES

The most conspicuous invertebrates of the clearings were crayfish (*Cambarus diogenes*). As the excavations dried up, their bottoms were full of the chimneys built by these crayfish, and their undercut banks were riddled with crayfish burrows. They undoubtedly proved attractive as food to the mink and to the bitterns which visited the clearings.

The molluscan fauna was represented chiefly by two species of *Lymnaea* and by the very abundant *Planorbis trivolvis*. An unidentified limpet also occurred in Clearing No. 9.

Although the plankton was not studied, there were obvious abundancies observed in the spring of 1942 which may be mentioned. *Daphnia pulex* occurred in numbers sufficient to color the water in several of the old clearings. Cyclopods were also noted as most abundant on the bottoms of several of these clearings.

The insect fauna of the dynamited clearings was that to be expected in pools of more or less stagnant water. Most frequently observed were in order: chironomids, notonectids, dystiscids, and corixids. Odonate and ephemerid nymphs were less numerous, while tipulid larvae, gyrinids, and hydrohpilids were rarely observed. These insects probably played a large role as food attractions to the visitors of the clearings, but this phase of the ecology was not investigated for lack of time. It was noteworthy, however, that at no time were mosquito larvae observed in any of these dynamited clearings.

EVALUATION OF THE TECHNIQUE

Before any evaluation of the various blasting methods or of the technique as a whole is attempted, it is essential that the goal of such development be very clearly defined. It is simple enough to evaluate blastings on the basis of volume of earth removed per unit cost, but this may not be the best measure. If the purpose is to maintain as much open water as possible in the clearings, then the depth of the excavation becomes the measure of evaluation. It is very important to remember that the higher the water-level the less depth is needed in excavations to preclude plant growth and maintain the clearing as a clearing (compare Plates 11C, 10D, 10E and 12D). If the required depth is 12 inches, then the evaluation must be based on, say, square-yards of area over 12 inches deep per year per unit cost. It is felt that this figure would apply for most of the clearings in the Ruthven Area, and Table 5 presents comparisons based on this criterion. Thus the average improvement made in 1941 amounted to 6.97 square-yard-years per cartridge of dynamite. And from this table it may

be deduced that two-line charges are the most efficient, averaging 15.11 square-yard-years per cartridge, or an annual cost of $38.50 per acre of surface over 12 inches deep. Expressed in terms of straight ditch, one rod wide at that depth, the cost would be $0.24 per rod per year or $76.80 per mile per year.

TABLE 5.—COMPARISONS OF CLEARINGS 1 TO 21 ON BASIS OF EFFECTIVE (OVER 12 INCHES DEEP) DURATION: EFFECTIVE AREA PER YEAR PER UNIT OF DYNAMITE USED

Clearing Number	A Years with Some Depth Over 12 In.*	B Original Area Over 12 In. Deep Sq. Yds.	C Sq. Yard Years A×B/2	D Dynam. Sticks Used	E Sq. Yd. Yrs. per Stick
1	7	74.7	212	172	1.23
2	6	89.8	271	141	1.93
3	6	79.4	238	168	1.42
4	6	53.1	159	153	1.04
5	7	105.8	370	181	2.05
6	6	94.0	282	204	1.39
7		no area over 12 inches deep			
8	8	46.6	186	99	1.88
9	57	233.3	6,549	310	21.10
10	7	160.3	560	160	3.50
11	19	181.3	1,722	160	10.77
12	7	187.7	657	530	1.24
13		no loss of area over 12 inches deep indicated			
14	5	58.8	147	103	1.42
15	7	89.0	312	214	1.46
16	16	157.1	1,257	160	7.82
17	25	234.0	2,925	320	9.12
18	24	186.6	2,239	214	10.43
19	14	54.8	384	104	3.69
20	37	73.3	1,356	167	8.10
21	10	635.5	3,178	636	5.00
Average					
1–8	6.5	77.6	245.4	159.7	1.56
9–21	19.0	187.6	1,773.9	256.5	6.97

* Computed on the basis of loss rates in the five-year period, 1941 to 1946.

It has been demonstrated that the blasting technique is more adaptable to the deeper parts of the marsh. Another way of expressing this is that excavations are more effective in the bulrush type of deep-water emergent vegetation than in the sedge types of shallow-waters. Superficially this may seem unfortunate because the latter vegetation is more often in need of opening up. There is, however, a very important and easily overlooked consideration. Will the creation of interspersion alone render sedge marshes such as the Oppedahl Tract suitable as nesting cover for waterfowl? Is lack of open water really the *limiting* factor in nesting use of such areas? Both questions may be answered in the negative. The very fact that sedges dominate a marsh is indication enough that water depths are generally inadequate for the nesting of diving birds and coots. Such areas commonly become dry early in the summer, so that inducing these birds to nest may be inviting disaster to nesting attempts.

Upland nesting ducks like teal, mallard, and pintail, may nest in sedge marshes, but nesting success, as observed in such habitat in Iowa, is low because water generally stands in late spring and the least rise in water level destroys the nest. In short, lack of open water in sedge communities should be interpreted as an indication of *general* unsuitability of the habitat for nesting of ducks, a deficiency which artificial interspersion by itself will not necessarily correct. The most that can be expected of dynamited clearings in such habitat is the possible rendering of surrounding upland more attractive to upland nesting waterfowl. They may also be valuable in improving duck-hunting conditions in this type of marsh.

It is felt on the basis of studies in Iowa that blasted excavations are of much greater value in the deep-water emergent vegetation such as round-stemmed bulrushes, cat-tail, and bur-reed. It must be appreciated, however, that because of the lower elevations and consequent higher water-levels, these areas are usually more attractive to muskrats and are therefore more likely to be naturally interspersed with open water. Nevertheless, summer precipitation is often low enough to make even this habitat dry (Plate 12D), in which case the dynamited holes furnish emergency supplies of water to broods and habitants of the marsh in general. A prolonged drought can usually be expected to (1) intensify the vegetative growth of deep-water emergents, and (2) drive out the muskrat population. Both these together will result in a solid growth of the otherwise desirable emergent cover. Disease or excessive trapping of the muskrat population may reduce these natural croppers of the vegetation and thus allow the growth of cover to become rank and solid, even when water levels are relatively high. There are therefore many instances of solid, deep-water, emergent growths which are severely in need of improvement by interspersion. Under such circumstances blasting may be most desirable, not only because of the interspersion created but because of the inducement to muskrat occupation. It has been amply demonstrated that blasted holes in marshes greatly improve the habitat for muskrats. In the Iowa experimental work it was noted that muskrats at once took over all the dynamited clearings, often building a lodge on the very bank of the excavation. Some ponds in Dewey's Pasture which, because of overwintering difficulties, had not held muskrats for years, produced striking catches of muskrats within two years after the blasting. In the final analysis there is no better way to maintain interspersion in a marsh than to maintain an adequate and controlled muskrat population. Good muskrat habitat is synonymous with good duck habitat.

RECOMMENDATIONS

Perhaps no consideration is more important than that the shallower the locale of a blasted hole the greater depth of excavation will be required to keep the hole clear of vegetation. Blasting should be done over hardpan if possible, and in a way to penetrate it. The coarser this hardpan the better. For maximum efficiency the water table should be at the surface or less than four inches below it at the time of blasting. A moderate to strong wind away

from the axis of the charge will be helpful in keeping debris from falling back into the excavation; the wider the proposed excavation the more essential this would be. It is recommended that blasting be done at a time when climatological records indicate a probable rise in water level subsequent to the blasting. Charges of four sticks or less should be pushed into the mud end to end until the top of the topmost stick is 18 inches below the surface, and should be spaced two feet on centers in a row. In two-line charges, the rows should be four feet apart. Charges of more than two rows are too inefficient to consider.

Two after-blasting treatments are recommended for trial. One is the planting, as soon after the blasting as feasible, of a good sod-former throughout the area of mud flat in order to check erosion. The other is the periodical eradication of emergent vegetation from the excavation proper, using some good herbicide.

In a large tract of marsh, blasted holes should be located strategically. Studies in the Ruthven Area have indicated that dynamited ditches will be of little use to any game bird species unless they are located where only open water is lacking in the total habitat requirements for that species. For diving ducks and coots, therefore, the excavations should be in portions of the marsh grown to "shaft" emergents (round-stemmed bulrushes, cat-tails, bur-reeds, reed grass, etc.) and where water will stand over eight inches deep in the nesting season. It must be remembered also that for full use during the nesting and rearing season, these birds require near at hand large and permanent bodies of water. For rails and possibly for gallinules, the ditches should be where the vegetation is a mixture of shaft and foliose (sedges and grasses) emergents and where water will stand from 4 to 10 inches deep in the nesting season. For puddle ducks, excavations should be located as close as possible to good upland nesting cover, and if this means blasting in shallow portions of the marsh it must be borne in mind that greater depth will be required to maintain these as effective clearings.

Large tracts of marsh cover could be opened up with a scattering of 6- to 10-rod long ditches at intervals, as recommended by Low (1945), of 100 yards. For water holes in extremely dry seasons, double-shot post-hole ponds should likewise be scattered through the marsh. These deeper holes would serve not only as emergency waters for waterfowl and muskrats, but may also hold important food organisms (fish, crayfish, aquatic insects, etc.) over the critical period as a reservoir for quick repopulation of the marsh when desirable water levels return. Sedimentation rates being what they are (Plates 11B and 11C, 11D and 10D) and penetration of the hardpan being so desirable, heavier loads are recommended in line-charges. Although the "3 sticks every 2 feet" single-line charge has the greatest blasting efficiency, a more satisfactory cross-section insuring longer effective duration is obtained using the "4 sticks every 2 feet" formula (Figure 12). This requires three boxes of dynamite per 10 rods, and the cost might be $40 for this length. Expected duration as a clearing would range from five to 10 years depending on water levels. Reblasting after five years may be indicated. The

same reasoning which selected the four-stick over the three-stick charge impels recommendation of the two-line charge over the single-line charge (Figure 12). A "4 sticks every 2 feet, in two lines 4 feet apart" charge would require twice as much dynamite and cost twice as much as the above recommended single-line method. Expected duration would be more than doubled, however, and reblasting after 10 years could indeed be expected to produce virtually

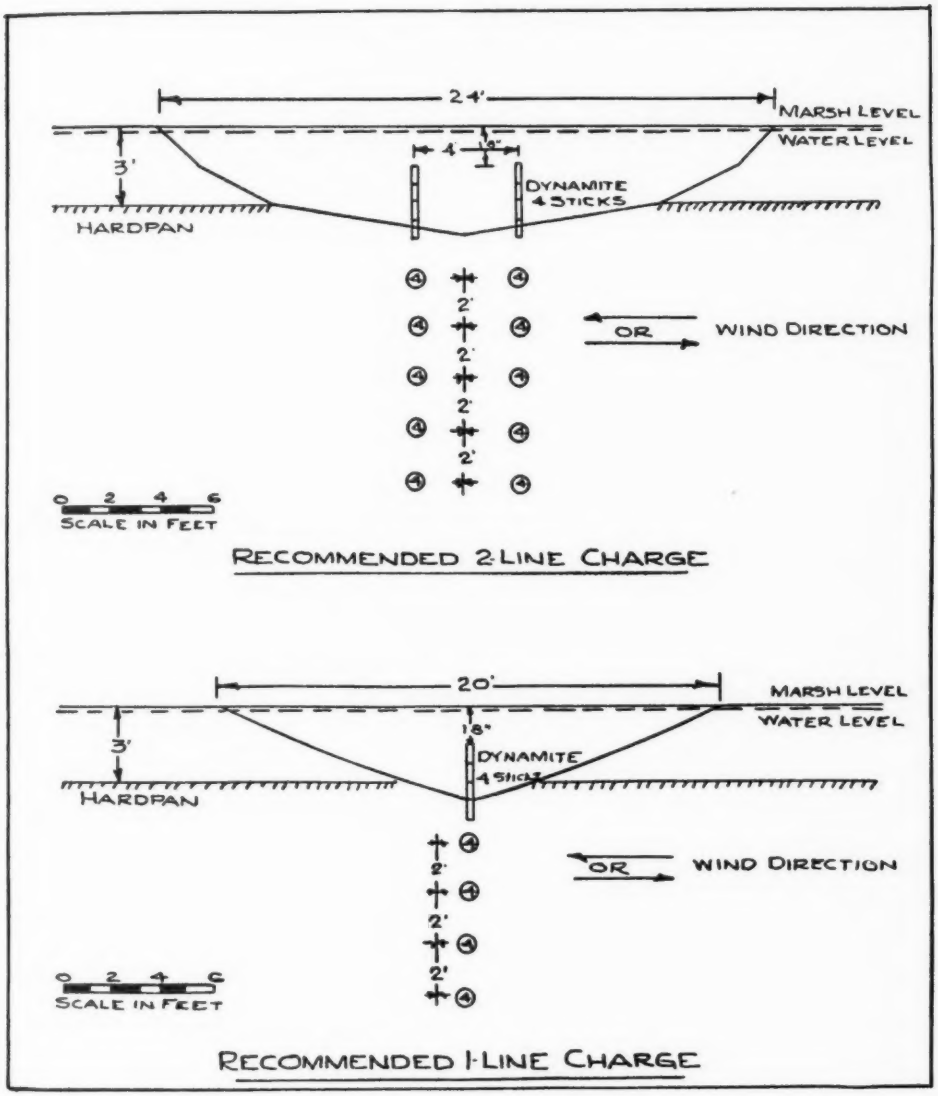

FIG. 12.—Recommended line charges for marsh blasting, based on investigations in Iowa.

permanent holes. The post-hole charges recommended (ex. Clearing No. 20, Plate 10D) would cost about $20 each. If all of 100 acres are to be opened up at 100-yard intervals, there would be required probably 25 line ditches (10 rods long) and 10 deep post-hole clearings. If the line ditches are two-line charges, as recommended ($80) the cost would be $2,200; if single-line charges are used

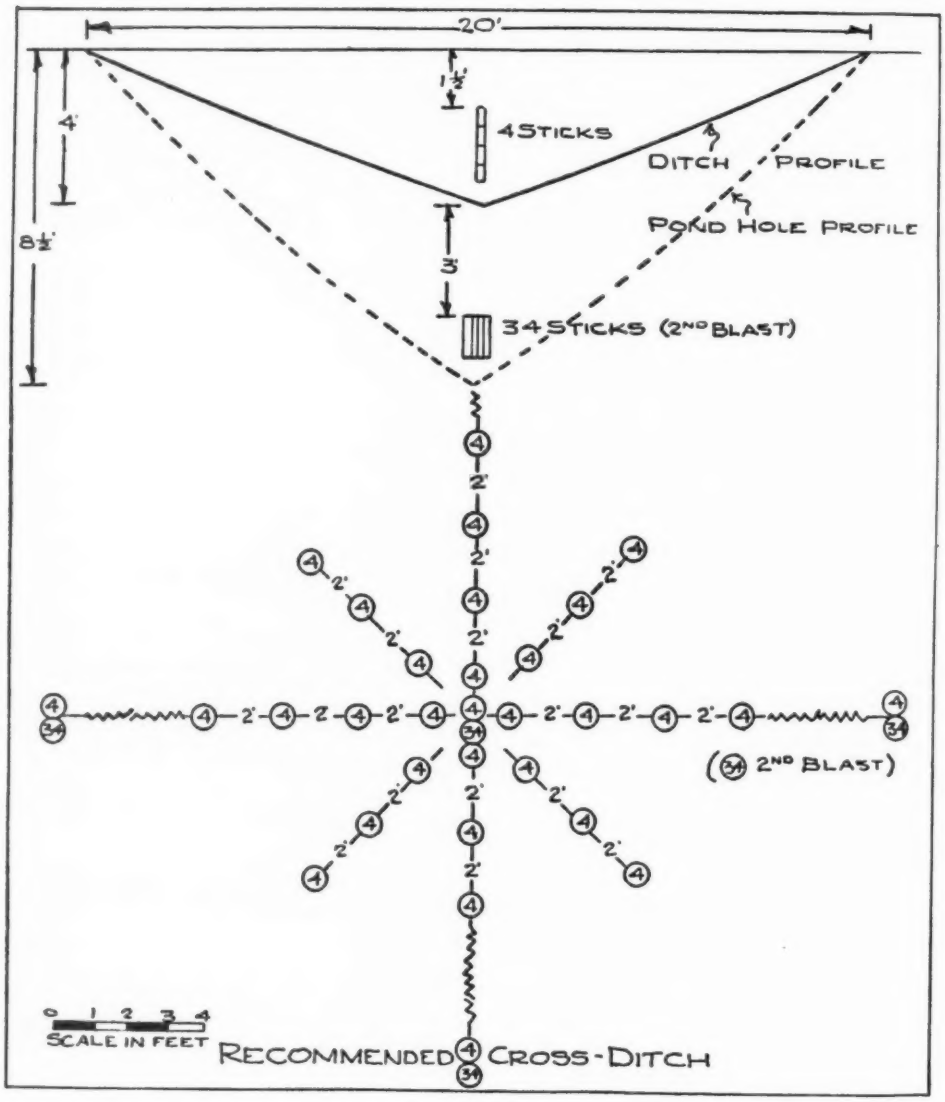

FIG. 13.—Recommendation for cross-shaped charge for opening up centers of shallow ponds, based on investigations in Iowa, particularly with Clearing No. 21.

the cost would be $1,200. These are maximum estimates, and it will seldom be indicated to open up an entire 100-acre tract, because of considerations of strategy as discussed above.

Throughout the prairie regions of the United States and Canada, there are many small, shallow kettle-holes such as those occurring in Dewey's Pasture. At their best these small ponds can support tremendous concentrations of nesting birds, but unfortunately they often remain choked with vegetation for years at a time and lose most of their value to wildlife. Clearing No. 21 (Plate 12C and 12D), blasted in the shape of a cross, suggested a highly recommended means of improving these ponds for waterfowl and muskrats. A cross-shaped clearings in the center of a five- to 20-acre pond would give maximum "edge" and interspersion at a minimum cost. A charging method slightly varied from that employed in Clearing No. 21 should be most satisfactory (Figure 13). The 45° short loadlines between the main arms of the cross are needed to keep the center clear and well opened; they worked very well in Clearing No. 21. A desirable refinement would be a second blast of 40 sticks in a post-hole in the center and at the end of each main arm. This would leave five deep holes, well separated, to serve the food-reservoir purposes mentioned above. A ditch like this with arms 100 feet in length would then require nine boxes of dynamite and cost in the vicinity of $116. In a pond which holds three to four feet of water when full, a clearing of this kind in the center may be expected to last at least 10 years. A cost of $11.60 per year is not much to maintain a fair-sized pond in optimum productive condition. Observations in Dewey's Pasture indicate the added catch of muskrats alone may defray the expense.

In final appraisal, blasting, while it creates better interspersion, has little effect on the nest substrate value of the surrounding cover. This difficulty can be minimized by careful selection of the area to be blasted. Blasting should be used in the management plan only when manipulation of water levels proves impracticable in obtaining the desired relationship of open water to suitable nesting cover.

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DYEING BIRDS FOR IDENTIFICATION

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Man has used leg bands, paint, dye and feather marking in his attempts to recognize and study birds. Butts (1930) states that J. B. Watson used stains in coloring terns, a method which enabled him to follow successfully the nesting and homing activities of these birds. Dr. Butts worked with both dyes and pigment stains in his study of the chickadee and white breasted nuthatch, testing some 30 dyes and several paints and lacquers. He tested his dye solutions by applying them with a brush to domestic fowl, using alcohol as the solvent for all alcohol soluble dyes, and water for the others. He found no entirely satisfactory dye, but of those tested, fuchsin proved to be the best.

Price (1931) used pigment stains dissolved in carbon tetrachloride to color successfully California gulls.

Moffit (1942) succeeded in marking grouse with dye dissolved in 50 per cent water and alcohol. He found that a concentrated dye in this solution penetrated quickly, and did not fade perceptibly during a period of two months' exposure to desert sunlight or rain.

Evans and Holdenreid (1943) in their study of the Beechy ground squirrel, tested several dyes for marking these rodents. Of those tested, black was visible for the longest period, but nearly all faded beyond recognition in 30 days.

Leopold (1938) used dyed feathers for feather marking released birds. He collected the feathers, washed them in vinegar, and boiled them in a dye solution for 15 minutes. The feathers were fastened to the bird in the approved fashion after the dyeing process was completed. This treatment gave a color recognizable for six months, but if unwashed or if boiled for a shorter time, they faded within two months.

Whatever marking technique is used for study purposes, it must be recognizable at a distance of from 100 to 600 yards with the aid of field glasses. With this as a consideration, dye seems to be the quickest, easiest, and most inexpensive method of marking.

By dyeing the feathers of individual birds, it is possible to recognize them and learn many of their habits. Dr. Butts (1930) conceded that dye is the best substance for marking, but found none suitable at the time of his study.

I have attempted to find a dye-solvent combination suitable for marking ring-necked pheasants; a dye that would retain a recognizable color from 90 to 120 days or longer, which makes it possible to study the life habits of resident wild birds as compared to those of non-resident birds released in the same area.

The dye, in order to be a suitable marking agent, should be non-toxic, fast acting in a cool solution, and capable of being used with some type of wetting agent or solvent so as to insure quick penetration and even coverage. For practical work, the dye must color in one short period of wetting, produce a visible color change on a ring-necked pheasant's plumage, and resist fading by both sun and water.

Of fourteen dyes tested, eight were furnished by the Chemistry Department of the State College of Washington and six were commercial dye samples. Those used were: Azo Rubine; Brilliant Green; Malachite Green; Diamine Blue; Diamine New Blue; Eosin; Indigo; New Methylene Blue; Scarlet Rit (Rit Products); Scarlet, Purple, and Carmine Batik (Eagle Brand); and Rhodamine B Extra and Auramine Concentrate (DuPont).

Pheasant skins and plumage collected during the hunting season furnished material for testing the various solvent and dye combinations. Dye solutions were at room temperature during the tests, and feathers dipped into the solutions were immediately removed and allowed to dry. The dry feathers were then washed four hours by a continuous spray of cold water.

Pure water solutions of the dyes failed to penetrate the feathers and gave only spotty coloring. Pure solutions of dye in alcohol and dye in acetate also failed to give even coloring. Solutions of 50 per cent water and alcohol gave fairly even coloring and fair penetration. Solutions of 50 per cent acetate and water showed no improvement of coloring and penetration over the pure solutions. Solutions of 33 per cent alcohol and 66 per cent water gave quick penetration and even coloration while the weaker 33 per cent solution of acetate gave poorer results.

Tests of three commercial wetting agents, added in quantities of less than one per cent to a water solution of the dyes, resulted in a great variation of penetration and color intensity depending upon the dye and wetting agent combination. These wetting agents cannot be used with all dyes, however, because of the formation of a precipitate in certain dye solutions upon their addition. Tests of various dye and solvent and wetting agent combinations are given in Tables 1 and 2.

All feathers dyed in the pure solutions of water, acetate, or 95 per cent alcohol and dye failed to stand the washing test. After washing 50 per cent and 33 per cent acetate dyed feathers, very little color remained showing that acetate was neither a good solvent nor wetting agent.

The 50 per cent solution of alcohol gave quick penetration and even coloration, but the dyed feathers upon washing, lost a perceptible amount of color. The 33 per cent alcohol solution gave equally good penetration and even coloration but with retention of a greater amount of color after washing. Lower percentages of alcohol failed to give as fast or as even a coloration.

Four dyes chosen as a result of the various tests (microscopic examination was used to determine penetration and intensity of color, and fading by water) were applied in a 33 per cent alcohol-66 per cent water solution to four ring-necked pheasants, two cocks and two hens.[1] The dyes were Malachite Green, Brilliant Green, Rhodamine B extra, and Purple Batik. The birds were held by the wings and the dye solution sprayed onto the feathers by means of a hand spray gun. Rolling the birds in a shallow pan of dye had been used successfully in a previous experiment.

In order to observe the effects of

[1] Testing of light fading was attempted on a carbon arc fadometer, but was abandoned because of mechanical failure.

TABLE 1.—RESULTS OF DYE TESTS ON RING-NECKED PHEASANTS

Dye	Water	Alcohol	Acetate	50% Alcohol	50% Acetate	33% Alcohol
Brilliant Green	Poor	Poor	Poor	C—Good P—Fair WF—Fair	Poor	C—Good P—Good WF—Good
Azo Rubine	Poor	Poor	Poor	C—Fair P—Good WF—Poor	Poor	C—Good P—Poor WF—Fair
Malachite Green	C—Fair P—Poor WF—Poor	C—Fair P—Poor WF—Poor	Poor	C—Good P—Fair WF—Fair	Poor	C—Good P—Good WF—Good
Diamine Blue	Poor	Poor	Poor	Poor	Poor	Poor
Diamine New Blue	Poor	Poor	Poor	Poor	Poor	Poor
Eosin	C—Good P—Good WF—Poor	C—Fair P—Fair WF—Poor	Poor	C—Good P—Good WF—Poor	Poor	C—Good P—Good WF—Fair
Scarlet Batik	C—Good P—Fair WF—Poor	Precipitate	Poor	Precipitate	Poor	C—Good P—Good WF—Poor
Purple Batik	C—Good P—Good WF—Poor	C—Fair P—Fair WF—Poor	Poor	C—Good P—Good WF—Fair	Poor	Good
Carmine Batik	C—Fair P—Fair WF—Poor	C—Fair P—Poor WF—Poor	Poor	C—Fair P—Fair WF—Poor	Poor	C—Good P—Fair WF—Poor
Rhodamine B. Extra	C—Fair P—Poor WF—Poor	C—Fair P—Poor WF—Poor	Poor	C—Good P—Fair WF—Fair	Poor	Good
Auramine Conc.	C—Fair P—Fair WF—Poor	Poor	Poor	Fair	Poor	C—Fair P—Good WF—Good
Scarlet Rit	Poor	Poor	Poor	Poor	Poor	C—Fair P—Poor WF—Poor
Indigo	C—Fair P—Poor WF—Poor	Poor	Poor	C—Fair P—Fair WF—Poor	Poor	C—Fair P—Fair WF—Poor
New Methylene Blue	C—Fair P—Fair WF—Poor	Poor	Poor	Fair	Poor	C—Fair P—Good WF—Good

C—Ability for even, intense coloration.
P—Even, thorough penetration.
WF—Resistance to water fading.

TABLE 2.—DYES PLUS WETTING AGENTS

Dye	−1% Tergitol	−1% Monoethanol Amine	Ultrawet
Rhodamine B Extra	Good	C—Good P—Poor WF—Poor	Precipitate
Auramine Conc.	Precipitate	Fair	Precipitate
Carmine Batik	Precipitate	C—Good P—Fair WF—Fair	Precipitate
Scarlet Batik	Precipitate	Precipitate	Precipitate
Indigo	Poor	Poor	Poor
New Methylene Blue	Fair	Poor	C—Fair P—Poor WF—Poor

C—Ability for even, intense coloration.
P—Even, thorough penetration.
WF—Resistance to water fading.

weather on the colored birds, they were placed in a wire pen on an exposed southwest slope, the only cover being a small spruce (*Picea engelmanni*) cut and laid in the pen. During the first four weeks of the test, 3.19 inches of rain fell, 1½ inches of it as snow. The average temperature was 35.8°F.

Fading was evident in all cases, with Rhodamine showing the least change. All birds could be identified readily at any distance at which the four colors could be separated by the eye.

The tests indicate that dyes are a practical, inexpensive, and quick method of marking pheasants for field study. With good dyes, properly applied, a pheasant will remain visibly colored for two months or longer when walking or feeding and for four to six months when flushed.

The solvent used, the wetting agent used, and the percentages of each compared to water will vary with the type dye used, and even with the color in the same dye type.

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OHIO STUDIES WITH REPELLENT MATERIALS WITH NOTES ON DAMAGE TO CORN BY PHEASANTS AND OTHER WILDLIFE[1]

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The Problem

Wild animals, particularly crows and the introduced ring-necked pheasant have long been blamed for digging out or pulling planted corn soon after it germinates. State conservation departments in the pheasant belt have, at least in some recent years, been the target of criticism by farmers for damage allegedly done by pheasants. On the other hand, many sportsmen and some personnel of conservation organizations have disputed this claim.

Some states have conducted investigations to determine the validity and extent of pheasant damage claims and to seek corrective measures if needed. Judging from recent correspondence, a number of additional states have similar investigations under way or are planning to conduct them. The following report on Ohio studies of this problem may be of some help to these investigators.

Extent of the Problem

Complaints of pheasant damage in Ohio come largely from counties in the comparatively level lake and glacial till plain of the northwestern part where intensive row cropping is followed. The chief complaints are for (a) pulling of recently planted corn in spring, (b) pecking of ripening tomatoes in late summer, (c) shattering of grain (notably soybeans) in the fall and (d) consumption of corn left out in the shock. This report deals only with the pulling of corn. It summarizes studies conducted in 1943, 1944, 1946 and 1947 to determine the extent of corn pulling and to test the effectiveness of certain materials as repellents.

Observations were made from blinds, automobiles or other suitable shelters adjacent to cornfields to determine if and how pheasants pulled corn. Both cocks and hens were observed digging out and eating kernels of corn attached to plants, usually for a period of seven to ten days after the corn was up and before it reached a height of four inches. In one instance a female with eight chicks was seen getting corn before the corn had actually appeared through the soil.

[1] The assistance of Messers John Babb, Jr., Kenneth Chiavetta, Eugene Dustman, Paul Moore, John Olive, John Oney, Lloyd Webb and William Wiseman, all students at the Ohio State University, is acknowledged. Mr. Ed Nash, in charge of the State Game Farm at Urbana, Ohio, furnished the birds used in the experiment and cooperated in the studies conducted at the Game Farm. The assistance of several county game protectors is gratefully acknowledged. Thanks are due also to Drs. E. R. Kalmbach and Donald Spencer for suggestions and for furnishing excellent materials for testing. Dr. L. E. Hicks participated in the early phases of the study.

[2] The Ohio Division of Conservation and Natural Resources, the Ohio State University, the U. S. Fish and Wildlife Service and the Wildlife Management Institute cooperating.

EXPLANATION ON FACING PAGE

Most of the damage caused by hens was confined to the marginal rows of corn adjacent to nesting cover. Cocks ranged all over the fields although at times they were observed feeding with the hens. The usual procedure was for a cock or hen to peck the soil away from the kernel until it was exposed, to then pluck and swallow it and to then move on to the next plant where the performance was repeated. Sometimes all of the plants in a rod or more of rows were dug out without interruption. A cock bird and two hens were once observed to dig out 79 stalks of corn in 20 minutes. This manner of exposing the corn usually left a hole of characteristic shape useful in recognizing evidence of pheasant damage (Plate 13, *A* and *B*). It may be characterized as a shallow inverted cone with a slight slope on one side at the lip of which is a slight accumulation of soil. Bits of the seed coats of sprouted kernels often remain in or near the hole from which the corn was dug.

Particular pains were taken to determine whether or not there was any relationship between the corn pulling tendencies of pheasants and the presence of cutworms at the base of corn plants. No such relationship was evident. Pheasants during early morning hours were observed to ignore plants which had been severed by cutworms during the previous night even though the cutworms were still present under loose soil at the base of the plants. It is quite likely that the cutworms found in pheasant crops and stomachs during the corn planting season were larvae obtained in meadows or possibly those still present on corn plants during the early hours of the morning.

After positive evidence of pheasant damage was established, an 11-county field check was conducted. A total of 139 corn fields at a comparable stage of growth (2–4 inches in height) was examined for evidence of damage. Seventeen or 12.2 per cent of these fields had been damaged to some extent. Significant losses necessitating replanting were evident in four plantings. In these fields, losses aggregated 5 per cent, 13 per cent, 19 per cent and 24 per cent respectively of the total stand. All of these fields were adjacent to long established pheasant refuges. The remaining fields sustained losses of less than one per cent of the total stand. Usually such losses were confined to the marginal rows adjacent to good cover.

County game protectors in the pheasant belt reported an aggregate of 69 pheasant damage complaints, 75 requests for repellent materials to put on seed in anticipation of damage and 28 requests for corn to be spread around fields to forestall damage. County agricultural agents in the same area indicated that they annually receive about 100 similar calls per county.

EXPLANATION OF PLATE 13

PLATE 13.—*A*. Characteristic digging of corn by ring-necked pheasants on muck soil, Hog Creek Marsh, Hardin County, Ohio. Note the slight slope on one side and the accumulation of soil above the slope. The walls of the hole are usually steeper in loam or clay soils. *B*. Characteristic damage by cutworms. Note the ragged edge of the cut stalk. The cutworm was, as is usually the case, found near the base of the severed plant and sheltered only by a few large aggregations of soil.

EXPERIMENTAL WORK WITH REPELLENTS

The methods devised to avoid corn pulling include among others the use of homemade and commercial repellents, deep planting, use of scarecrows, and spreading of a trail of corn around the edge of the fields at planting time. All of these methods have been in use for many years despite the fact that none of them has been proved to give consistently good results. Reports from farmers, conservation officials and county agricultural agents differ greatly with respect to the repellent effectiveness, effect on seed germination and ease of handling. The materials that have been tried, in addition to commercial repellents include: coal tar, turpentine, kerosene, camphor oil, carbolic acid, fish oil, copperas and lead oxide.

The more promising of these materials and several additional ones were selected for experimental trials. The criteria for selecting materials were:

1. Reputed successful previous use.
2. Repellent qualities—astringent, emetic, bitters, odor, color, or texture.
3. Effect on germination.
4. Availability—cost, commercial availability.
5. Ease of application and use.

Many commercial materials such as Fermate, Arasan and various asphalt-sulphur mixtures were early ruled out because it was difficult to fix them to grain without rendering it unsuitable for use in a corn planter. Other materials, particularly oils, greatly reduced germination. The commercial repellents, all of which had a coal tar base, retarded germination 24 or more hours and resulted in some reduction of germination.

EXPERIMENTS WITH CAGED PHEASANTS

After preliminary laboratory tests to eliminate materials harmful to germination or that would not work well in a planter, tests were conducted by feeding various combinations of treated and untreated corn to pheasants confined in cages. A cage consisting of eight hens, one of eight cocks, and a mixed pen of five hens and four cocks were used for the trials. Whole shelled corn was fed at first and later, corn sprouted in greenhouse flats, was fed. The tests were conducted for a 30-day period. The materials used included: terpene mercaptan, lead oxide, a green aniline dye, an iron salt of nitrose beta-naphthol, phthalocyanide blue dye, para-toner red dye, ground naphthalene, three commercial repellents (including one dispensed gratis to farmers by the Ohio Division of Conservation and Natural Resources), commercial coal tar, commercial kerosene and a phenol soap. (The dyes were made available by the Denver Wildlife Research Laboratory.)

The green aniline dye followed by the commercial repellents gave the best results, but none of the materials was more than 60 per cent effective. The green dye was found to have a moderate fungicidal value. Lead oxide treatment which has been advocated for use in Wisconsin (Loyster, 1944) was ineffectual. Only 23 per cent of the grain treated with this material were refused by pheasants. Similar results were obtained with both whole corn and sprouted corn. These experiments although conducted under unnaturally

crowded conditions, show that under such conditions, healthy pheasants, of both sexes, will eat corn treated with commercial repellent materials, materials used locally by farmers, and a variety of other substances having a strong offensive odor, ill taste (judged by human standards) or unusual color.

FIELD EXPERIMENTS

Trials with these same materials together with a promising asphalt-sulphur preparation provided by the Fish and Wildlife Service were conducted under field conditions. Arrangements for field trials on farms were made in Hancock, Hardin, Marion and Wood Counties through the aid of the county game protectors. Repellent-treated seed was planted in the marginal corn rows at or within a few hours of the time that the rest of the field was planted with untreated corn.

The fields were then carefully watched until the corn was too large to be damaged. The records obtained agree with the caged bird tests. None of the materials tried, including commercial repellents, gave sufficient protection from pheasant damage to justify their use for this purpose. Approximately 40 per cent of all the repellent-treated seed was eaten and the lowest loss was nine per cent. The materials were purposely used along field margins where the greatest amount of damage was expected. Under these circumstances, repellent treated corn was taken about as readily as untreated corn.

These experiments were repeated the following year (1944) on the Resthaven Wildlife Sanctuary and on the Urbana Game Farm. The results were essentially the same.

Three additional materials were tried at the Urbana Game Farm during 1946. These included a brilliant green dye, monastral green dye, and anthraquinone with a commercial repellent, as the standard for comparison. The corn was planted in a large holding field at the northwest corner of the farm in narrow strips alternating with strips of unharvested weedy clover-timothy meadow. Each strip contained eight rows of corn. Four full strip replications of corn treated with each material were planted. Four strips of untreated corn were planted as a check. Thus 160 rows of corn were under observation.

The area was visited after the corn came up and records were obtained on losses apparently due to pheasants. Although pheasants were actually observed to dig out corn in the strips, it is possible that some of the losses observed were occasioned by spermophiles. Strangely enough, untreated corn suffered lighter losses than treated seed.

Losses by June 13 after most of the corn had attained a height of 3–4 inches are as follows:

Untreated	9.2%
Anthra-quinone	22.2%
Monastral Green	23.1%
Brilliant Green	23.3%
Commercial Repellent	63.3%

These observations are similar to those obtained in previous years as indicated in Table 1.

Due to rains an interval of one week elapsed between the planting dates for the various strips of corn observed in 1946. It was apparent that a rain which

TABLE 1.—SUMMARY OF REPELLENT EFFECTIVENESS BASED ON PER CENT OF REPELLENT-TREATED SEED PULLED BY PHEASANTS 1943 AND 1944

Material	Per Cent Taken			Average % Taken	Remarks
	Hancock Co.	Hardin Co.	Wood Co.		
Red Dye	44.0	31.0	13.0	29.3	Flakes somewhat and does not flow freely in the planter.
Green Dye	24.0	59.0	9.0	30.6	Dyes easily. Flows freely. Handles very easily.
S-C.R.*	49.0	24.0	23.0	32.0	Prepares easily. Retards germination slightly.
G.&O.-C.R.*	36.0	44.0	28.0	36.0	Same
Coal Tar	40.0	51.0	17.0	36.0	Has tendency to cause kernels to adhere to one another. Retards germination slightly.
R-23†	57.0	26.0	29.0	37.3	Very gummy. Does not allow free movement of grain.
Kerosene	36.0	73.0	20.0	43.0	Easily applied. Delays germination slightly.
Naphthalene	43.0	75.0	12.0	43.3	Flaky—bulky—interferes with free movement of corn.
W-C.R.*	40.0	88.0	21.0	49.0	Same as other C.R.
Red Lead Oxide	68.0	60.0	27.0	51.6	Adheres fairly well with moderate loss of dust. Little effect on flow of corn. Possibly some fungicidal value.
Untreated	10.9	5.1	35.4	17.0	Based on adjacent untreated rows which are less susceptible to being pulled.

* Commercial Repellents. Initials are used to identify different materials without disclosing trade name.

† Asphalt-sulfur mixture provided by the Denver Wildlife Research Laboratory, U. S. Fish and Wildlife Service.

delayed the planting for several days extended the length of time corn in the field was vulnerable to pheasants, *i.e.*, the later planted corn was damaged for several days after the earlier corn was left unmolested.

It was also observed that damage to corn was greater in loose, sandy or muck soil than in heavy soil that had been packed by rain and had become hard upon drying. This was especially true if the rain came after the corn was planted but before it came up.

In 1947, recognizing the possibility that pheasants in previous years may have eaten the sprouts of undyed or untreated corn then turned to the treated corn, a different approach was used. The Urbana Game Farm was again used as an observational area; however, rather than planting strips of corn treated with various dyes and al-

ternating with strips of untreated corn, four strips were planted, June 20, with corn all dyed a brilliant green. These strips containing 30 rows of corn were placed in a field at some distance from any other corn and also separated by high fences making it very improbable that birds feeding in the corn strips had visited any other newly planted corn fields.

By July 2 it was found that 471 kernels of corn (approximately 6.1 per cent) had been pulled. On the three succeeding days of July 3, 4 and 5, additional sprouts were dug out as follows: 45, 22 and 5 at which time the corn had reached a height of about five inches, the soil had become dry and further damage insignificant. Thus a total of approximately seven per cent of the dyed corn was taken.

Daily observations made by John Babb, Jr., indicated that little if any of the damage was occasioned by small mammals and that the greatest portion of the damaged corn was pulled by red-winged blackbirds rather than pheasants. On frequent occasions these birds were observed digging around stalks of corn and taking the kernels. Rabbits were observed eating the tips of the green corn but never digging out the grains.

In addition to the Urbana Game Farm plots, three fields in Wood County were planted with corn dyed a brilliant green. All of these fields were in areas having a considerable number of pheasants. One and eight-tenths acres of a three and four-tenths acre field in Liberty Township were planted with dyed corn, the remainder with undyed corn. When examined July 2, by Eugene Dustman and William Wiseman, seventy sprouts of the undyed corn had been pulled by pheasants and only five sprouts of the dyed corn had been pulled. Much dyed corn which had been scattered on the surface of the ground had not been touched by pheasants or crows. Further observations on July 4 and 10 revealed no additional damage.

Another six and one-tenth acre Liberty Township field was planted about the middle of June with undyed corn. Pheasants destroyed most of the corn in this field which was redisced and planted with dyed corn June 24, 1947. The field was examined July 2 when the corn was about three inches high and no damage was seen. Further examinations on July 4 and 10 revealed no damage.

In Portage Township a six-acre field was planted with dyed corn June 25. It was examined July 5 and July 10 and no corn had been pulled.

Thus the results obtained in 1947 from using seed corn dyed a brilliant green varied considerably in the Urbana Game Farm plots and the Wood County corn fields.

It is interesting that many farmers who had complained about pheasant damage in years of pheasant abundance prior to 1943 registered no complaints in 1947 regardless of whether they had used repellents or not.

USE OF COMMERCIAL REPELLENTS BY FARMERS

Some farmers are well satisfied with the results obtained through using commercial repellents. Reports from game protectors in Fulton, Hancock, Hardin, Wood and Henry Counties indicate that they furnished, on request, com-

mercial repellents to at least 75 farmers during the 1943 planting season. Five of these farms were visited. On all five farms, some damage due to pheasants was evident. In one case, damage was more severe than any other observed where no treatment was used. On the other farms, damage was largely confined to the marginal rows and amounted to less than five per cent. These farmers were satisfied with the stand obtained.

USE OF A CORN TRAIL

Scattering ear or shelled corn in a narrow trail around the margins of corn fields a few days after planting has long been recommended in Ohio and other states. Seven cases where this method was used were studied (Hancock, Hardin and Wood Counties). In two instances, corn was not scattered until planted corn was coming up. Both of these fields suffered moderate losses particularly in the marginal rows. The remaining five fields suffered negligible loss along the margins and in the fields where corn was scattered, a day or more before the appearance of the shoots above the ground.

To apply the corn trail around a field it is recommended that the desired amount of corn be put in a grain bag, two corners of which are tied with heavy cord in such a manner that the sack can be suspended from one's shoulder; then by using one arm and hand around the middle of the bag to help support the weight and the other hand to regulate the flow of the grain from the open end of the bag a fairly even and continuous trail of corn can be scattered where needed.

SUMMARY AND DISCUSSION

Experiments with selected repellent materials and commercial repellents applied to seed corn gave unsatisfactory results in experiments with caged birds and in field trials. Shelled corn when scattered around the field margin in a narrow trail a day or more before the corn emerged from the ground gave fairly satisfactory results. From one to three bushels of corn are usually needed under Ohio conditions, depending on the length of field margin adjacent to good cover and the abundance of the pheasants. Pheasant damage is local and in some instances results in serious losses. All of the serious losses investigated occurred adjacent to or in refuge areas. Continued serious damage may be expected in such areas unless suitable repellents are found or an adequate amount of corn is placed around the field before corn emerges from the ground. Throughout the pheasant belt as a whole, damage to planted corn by pheasants is negligible. It amounts to much less than one per cent even in the best pheasant counties. The damage is, however, conspicuous, is easily recognized and is largely confined to field margins, although cock birds may feed here and there throughout a field.

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THE USE OF OVULATED FOLLICLES IN DETERMINING EGGS LAID BY THE RING-NECKED PHEASANT[1]

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The first report of experiments designed to develop a way for reading breeding history from pheasant ovaries has been published by Meyer, Kabat and Buss (1947). It was concluded that the ovulated follicle is a valid criterion for determining ovulation in the ring-necked pheasant, and it was demonstrated that the ovulated follicle is easily identified in the pheasant ovary up to 15 days post ovulation. At this time the remains of the follicle ranges from one to three millimeters in diameter, and has a reddish-brown color which varies considerably in intensity.

Casual examination of ovaries obtained during fall and winter months from wild pheasants one or more years of age revealed small reddish-brown structures between the small follicles of the inactive ovary. Ovaries from immature wild hens examined at the same time did not show these pigmented structures. These observations suggested that the pigmented structures are characteristic of ovaries from hens that have gone through at least one breeding season, and that these structures might be the terminal stages in the involution of ovulated follicles. Furthermore, the observations suggested that a method for determining the number of eggs ovulated by examining the ovary at a time subsequent to the breeding season could be developed. Experiments were conducted to test these hypotheses and to determine whether a method could be developed for estimating the number of eggs laid by pheasants. The experiments and the method are described in this second report. The application of this method to the study of factors affecting reproduction in wild pheasants will be presented in a third report.

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Materials and Methods

The main requisites for determining how long ovulated follicles can be identified and whether they can be used to estimate the total number of eggs laid by pheasants consist of obtaining egg-laying records and comparing the ovulated follicle counts for individual hens. A correlation was calculated between the number of eggs laid and ovulated follicles counted. The method used to acquire these data was to pen pairs of year-old pheasants separately, to observe and record the egg-laying performance of each hen and then to kill and count the ovulated follicles. Some of these hens were killed during the laying stage and others up to 348 days after they had laid their last egg,

so that their ovaries would show the various stages in the involution of ovulated follicles up to the time of complete resorption.

Pens. Getting an accurate record of the eggs laid by each hen involved two opposing difficulties. It was necessary to have pens that were conducive to natural egg-laying and yet permit the finding of all eggs laid. The ideal pen would have been one that was a facsimile of the wild habitat. The large size of such pens, however, would make it difficult to find all the eggs that were laid. The practical solution was to use pens of the type utilized at the State Experimental Game and Fur Farm for breeding purposes and for rearing pheasant chicks after they are three weeks of age.

The pens used for breeding purposes were the same type used in the first study by Meyer, Kabat, and Buss (1947), and they will be referred to as "small pens" in this paper. These small pens which had a width and length of 16 feet and were 7 feet high contained only a few annual weeds and some winter rye which was soon eaten or trampled.

Pens of the type used for rearing pheasant chicks were 100 feet long, 40 feet wide, and 7 feet high. Biennial sweet clover (*Melilotus officinalis* and *M. alba*), lambsquarters (*Chenopodium album*), common ragweed (*Ambrosia artemisiifolia*), wild aster (*Aster* sp.), bluegrass (*Poa pratensis*), goldenrod (*Solidago* sp.), and quack grass (*Agropyron repens*) developed a dense stand of cover in most of the pens. A few of these pens lacked vegetation, and it was assumed that the pheasants occupying them would be late in starting to incubate a clutch. It was learned later, however, that the birds in the pens having sparse cover laid and started incubating at the same time, and in two cases earlier than did those in pens with good cover. In general the cover found in most of the enclosures appeared excellent for nesting. These pens will hereafter be referred to as "large pens."

A pan of water and a hopper of commercial laying mash were placed in both the large and small pens to assure accessibility of food and water at all times.

Egg laying and pen observations. The first step taken to insure the procurement of accurate egg-laying records was to prevent eating of eggs by the penned pairs. This was accomplished by paring the bony parts of the mandibles. The operation did not interfere with feeding. Bills had to be pared at least once a month up to the time the hen began to incubate.

All pens were examined daily until the first eggs were laid. Thereafter weekly visits were made to avoid constant disturbance of the hen. At the time the experiment was planned it was assumed that artificially-propagated pheasants penned under conditions simulating wild habitat would probably drop a few eggs at random and then lay from 10 to 15 in a nest and incubate them. These assumptions were based on the studies of Hamerstrom (1935) and Stoddard (1931) who found that random or promiscuous laying was common by pheasants and bobwhite quail respectively. Also, Hamerstrom (1935) reported averages of 12, 10 and 12 eggs laid in nests during three successive seasons in Iowa, and Wisconsin nesting studies by Buss (1941) showed that an

average of 15 eggs had been laid in nests.

What was actually found was that the first 1 to 20 eggs laid by each hen were not laid in a nest but were scattered throughout the pens. These eggs were left in their original positions until the hens began laying in nests, at which time the scattered eggs were gathered and removed from the pens. Most hens abandoned their first nests for no obvious reasons. When a hen started laying in a second nest the eggs were removed from the abandoned nest. A precaution taken to prevent hens from abandoning nests or broods was to remove cocks from the pens as soon as a hen began to lay in a nest.

It was at first believed that the large number of eggs laid promiscuously by the penned birds was a characteristic of captive birds, and that they would not incubate an average-sized clutch, *i.e.*, those laid in a nest. However, by late May most of the hens in the large pens had laid their last 4 to 11 eggs in nests, and had begun to incubate them. It was not expected that those hens in the small pens would also lay their eggs in nests and incubate them. However, 11 of the 18 hens confined in these pens became broody, and they were allowed to incubate their eggs for 20 days. These and the ones that did not become broody were then transferred and grouped in small pens for simplicity of handling. None of them laid again after the transfer.

Killing of hens and the making of ovulated follicle counts. At a selected time, hens were killed by severing the neck vessels. Their ovaries were removed immediately and fixed in a solution of 30 parts of formaldehyde, 10 parts of 95 per cent alcohol, 10 parts of glacial acetic acid, and 50 parts of water. They remained in the fixative from 30 to 150 days, depending on when it was possible to remove them to count the ovulated follicles.

The active ovary of laying hens has a likeness to a bunch of grapes, and the large ovulated follicle can be likened to a grape hull from which the pulp has been squeezed. Such follicles are easy to identify since they have a smooth edge opening opposite their point of attachment. Mechanical ruptures which occur occasionally leave openings with rough or jagged edges.

The opening which marks the place where the egg was extruded is no longer visible after the follicle involutes to less than one millimeter, and thereafter color and shape are the distinguishing characters as has been shown in the first report. Also, it was shown that ovulated follicles less than three millimeters in diameter were usually pigmented. The color of the pigment varied from bright reddish-brown to tints and shades of red. The term ovulated follicle is used in this paper to refer to all structures described in this and the above paragraph. With the exception of a few cases, follicles which have not ovulated and from which the yolk is being resorbed to not show pigmentation.

The actual procedure for counting ovulated follicles involved: (1) finding tissues characterized by pigment and shape which represented ovulated follicles, and (2) removing and counting this tissue whether it was visible as a pigmented structure or as an ovulated follicle with a typical opening. Low-power lenses were used when the follicles were very small.

RESULTS AND DISCUSSION

The data obtained from hens confined in the large and small pens during both 1943 and 1944 are shown in separate tables (Tables 1, 2, and 3) because each group (A, B, and C) was subjected to a different experimental environment. For the purpose of showing the correlation between egg-laying records and ovulated follicle counts, the data in these tables are arranged vertically in order of time elapsing after the last egg was laid. The data are arranged horizontally in such a manner that the complete egg-laying history of each bird is presented in chronological order.

To express the correlation of the ovulated follicles for individual hens with the number of eggs they had laid, the term "ovulation factor" is used. This factor is obtained by dividing the number of ovulated follicles by the number of eggs and multiplying by 100.

In twenty cases more structures were classified as ovulated follicles than there were eggs found, and in eighteen cases fewer structures were classified as ovulated follicles. Some of the factors which might account for the discrepancies are: (1) non-ovulated follicles that involute and leave pigmented structures (Davis, 1942a) which cannot be distinguished grossly from those of ovulated follicles, (2) the ovulation of eggs into the body cavity and their failure to enter the oviduct, (3) laying of double-yolked eggs; each egg leaving behind two ovulated follicles in the ovary, (4) eating of eggs, (5) sloughing of a part of the ovary containing post-ovulatory follicles (Hutt, 1939; Parker and Kempster, 1940) and (6) disease and injury.

In cases where the ovulation factor departs from 100, any one or more of the factors listed above might combine to increase the error.

At this point the question might be raised, with such possible sources of error, as to with what degree of accuracy can the actual number of eggs ovulated be predicted from tallies of ovulated follicles found in the ovaries of wild pheasants whose laying records are unknown? Before this question can be answered, it is necessary to first test whether there is a significant correlation between the ovulated follicles found in the ovary and the number of eggs laid by each hen in the experiments. Only hens killed before January 1 are included in the correlation analysis because after this date many of the ovulated follicles have undergone complete resorption.

The association between the ovulated follicle counts and the eggs laid was studied by means of the standard methods of correlation and regresssion as described by Snedecor (1946). Indirectly, through these methods of analysis, it was possible to determine the length of time ovulated follicles can be identified and, directly, the extent to which they may be used to estimate the number of eggs laid.

GROUP A

Table 1 shows the data from 14 ring-necked pheasants, Group A, confined in large pens in 1943. Of these 14 hens, the first three listed in the table were killed while still in the laying stage. The remaining 11 hens were killed at intervals varying from 0 to 245 days post ovulation to determine how long after ovulation a follicle can be identi-

fied. In two cases this time could not be determined with less than a three-day error, because observations were made weekly, and the last egg was laid in the interim.

The ovulation factors in Table 1 show some variation between individuals and also offer indirect evidence that few, if any, ovulated follicles had been completely resorbed in the ovaries of hens killed before September 6. The data indicate that complete resorption might be the cause for the lower correlation in those cases showing an ovulation factor less than 100, particularly for the last three hens of this group.

The correlation between eggs laid and the number of ovulated follicles found for the Group A hens, killed before January 1, is .90, a value which is highly significant.

The highly significant correlation between these two variates in Group A implies that the number of eggs laid by a hen pheasant can be ascertained from the ovulated follicles found. Additional evidence will be presented in the correlation analyses of Groups B and C.

TABLE 1.—OVULATION HISTORY OF 14 CAPTIVE HEN PHEASANTS CONFINED IN LARGE PENS (GROUP A, 1943)

Band No. of Bird	Laying Dates		Date Bird Was Killed	Days after Last Egg*	No. of Eggs Laid	No. of Ovulated Follicles	Ovulation Factor†
	First Egg	Last Egg					
2500G	4/16	5/25	5/25	0	39	37	95
96G	4/12	5/25	5/25	0	29	34	116
95G	4/13	5/25	5/25	0	46	52	113
2467G	5/3	6/6	6/13	1–7	28	26	93
2465G	4/22	5/25–30	6/6	7–13	31	32	103
503G	4/17	5/14	6/5	21	25	25	100
501G	4/16	7/4	8/8	35	49	55	112
9980D	4/9	6/5	7/18	42	57	65	114
9981D	4/15	6/5	8/18	63	51	44	86
9982D	4/12	5/5	7/18	70	21	25	119
508G	4/16	5/30	9/6	119	42	45	107
514G	4/15	5/25	10/25	154	38	26	70
2466G	5/3	6/20	12/1	168	34	29	85
522G	4/13	6/5	2/2	245	47	30	64

* Time between laying of last egg and killing of hen.
† The ovulation factor is obtained by dividing the number of ovulated follicles by the eggs laid, and multiplying by 100.

GROUP B

Table 2 shows the data from six pheasants, Group B, which were also confined in large pens on March 10, 1944. The number of days between the last egg laid by a hen and the day she was killed varied from 21 to 289 days.

The difference between the number of ovulated follicles found and the number of eggs laid by hens 15668F and 15694F may be due to either chance variation in sampling or some other cause inherent in the physiology of the bird. A possible explanation for these extreme differences is found in the history of these two birds.

Hen 15668F was subnormal in weight which was associated with her atypical laying and incubating performance as compared to the other hens in Group B, *i.e.*, she laid 15 eggs in as many days and began incubation two weeks in advance of any other hen in Group B.

The ovaries of 3 of 84 wild hens collected in 1943 and 1944 contained some ova often ruptured or the yolk material escaped without a definite break in the yolk membrane."

The ovulation factor of hen 15694F is more easily explained. She laid a number of extraordinarily large eggs, and when two of these were broken they were found to contain double yolks.

Since there were only four hens in Group B which were killed before January 1 and because two of these had abnormal laying records, the correlation between ovulated follicles and eggs laid was not calculated.

Included in this table are two birds (15692F and 15674F) which were killed after January 1, 1945, and whose ovulation factor showed a high correlation between eggs laid and ovulated follicles.

TABLE 2.—OVULATION HISTORY OF SIX CAPTIVE HEN PHEASANTS CONFINED IN LARGE PENS (GROUP B, 1944)

Band No. of Bird	Laying Dates		Date Bird Was Killed	Days after Last Egg	No. of Eggs Laid	No. of Ovulated Follicles	Ovulation Factor
	First Egg	Last Egg					
15668F	4/15	5/1	5/23	21	15	29	193
15684F	4/17	5/16	7/11	56	26	29	111
15694F	4/24	6/30	10/16	105	42	66	156
15605F	4/22	6/2	10/27	147	35	39	111
15692F	4/19	6/2	2/24/45	267	41	43	105
15674F	4/22	6/5	3/21/45	289	40	48	120

atypical structures which may or may not have been ovulated follicles. This atypical situation was correlated with subnormal weights.

In another case a crippled wild hen collected in July, 1946 weighed 781 grams, her entire right side was atrophied, and her ovary which was necrotic contained 54 pigmented structures, half of which were very atypical for ovulated follicles. This condition of the ovary may have been due to infection. In this regard it is noteworthy that in the domestic fowl the condition referred to as "ruptured yolk" was found to be associated with infections of *Pasteurella avicida, Salmonella gallinarum* or *S. pullorum* by Hoffman (1932). In the cases in which *P. avicida* was recovered, Hoffman found that there were "definite changes in the ovaries of many of the birds, and the

GROUP C

Table 3 shows the data from 18 pheasants, Group C, that were confined in small pens on March 10, 1944. The first hen listed in the table was killed while still in the laying stage, and the remaining 17 were killed from 28 to 348 days post ovulation.

The value of "*r*" for Group C in Table 3, which includes 12 hens killed between July 9, 1944, and January 1,

TABLE 3.—OVULATION HISTORY OF 18 CAPTIVE HEN PHEASANTS CONFINED IN SMALL PENS (GROUP C, 1944)

Band No. of Bird	Laying Dates		Date Bird Was Killed	Days after Last Egg	No. of Eggs Laid	No. of Ovulated Follicles	Ovulation Factor
	First Egg	Last Egg					
15706F	4/25	7/9	7/9	0	64	72	112
15726F	5/11	6/15	7/13	28	33	34	103
15764F	4/23	7/9	9/9	56	55	51	92
2456G	4/30	7/10	10/7	84	44	43	98
15774F	4/26	6/28	10/16	105	56	64	114
15720F	4/13	7/4	11/7	126	76	52	68
1884G	4/29	7/4	11/7	126	34	36	106
15794F	4/29	6/30	11/24	144	49	37	76
2469G	4/12	7/6	11/30	147	65	48	74
15790F	4/25	6/30	11/24	147	39	44	113
2468G	4/23	7/10	11/20	168	47	59	125
15736F	4/21	6/28	12/13	168	50	46	92
15716F	4/26	7/12	2/27/45	230	52	19	36
15722F	4/11	7/2	2/27/45	240	65	55	85
513G	4/13	7/13	4/2/45	263	64	35	54
15780F	5/2	7/1	3/27/45	271	41	18	43
15724F	5/1	6/28	3/27/45	272	43	32	74
15744F	5/7	7/10	4/20/45	348	48	16	33

1945, is .62 which is a significant correlation.

The six hens in Group C that were killed after January 1, 1945, showed ovulation factors from 36 to 85 indicating that a considerable number of follicles might have involuted beyond recognition.

Significance of correlations. The total number of eggs laid by any one of the birds discussed in the preceding paragraphs far exceeded the number found in nests of wild pheasants as generally reported. On the basis of these reports it was believed at first that the large number of eggs laid by the penned birds was not typical of wild pheasants. However recent observations which will be published in a subsequent report indicate that a similar number of eggs is laid by at least some wild pheasants.

Although Group B contained only four individuals (including two aberrants) that could be compared with Groups A and C, each of the three groups yielded evidence that ovulated follicles and eggs found are associated. When combinations of Group A+B, and A+B+C were treated as two separate units, highly significant correlation coefficients were also found. The correlation coefficients, "*r*," for the eggs laid and the ovulated follicles are shown in Table 4. Combining the groups has the advantage of showing that the larger samples showed significant correlations between ovulated follicles and eggs laid even though they contained some individuals with extreme ovulation factors. For the purpose of applying the experimental data to wild pheasants, all of the hens in the three groups that were killed before January 1, and whose ovaries contained less than 45 ovulated follicles were grouped and analyzed together. The correlation coefficient of this last group is .74, a highly significant value.

Up to this point in the discussion it has been shown that all ovaries pro-

duced eggs and contained ovulated follicles. More than a hundred ovaries from hens that had not reached breeding age were examined. None of these immature ovaries contained tissues which could be diagnosed as ovulated follicles. However, the ovaries of 93 hens that were known to have laid eggs all contained ovulated follicles. One

TABLE 4.—STATISTICAL ANALYSIS OF THE CORRELATION BETWEEN OVULATED FOLLICLES AND EGGS LAID, AND THE REGRESSION OF EGGS LAID ON OVULATED FOLLICLES*

		Group Means				
Group	No. of Hens	Eggs Laid	Ovulated Follicles	Correlation Coefficient	Regression Coefficient	F Value
A	13	38	38	+.90[a]	.75	45.6[a]
C	12	49	51	+.62[b]	.69	6.2[b]
A B	17	36	39	+.80[a]	.66	27.3[a]
A B C	29	42	43	+.78[a]	.79	37.9[a]
A B C selected†	18	34	34	+.74[a]	1.00	13.4[a]

* The methods of statistical analysis used in this table are taken from Snedecor (1946). [a] Highly significant at the .01 level. [b] Significant at the .05 level.

† The hens in this group consist of those whose ovaries contained less than 45 ovulated follicle remains.

efficient of all the groups treated statistically above has shown that with the exception of Group B, the two variates, number of ovulated follicles found and eggs laid are associated significantly. The remainder of this discussion will be concerned largely with showing by use of the regression treatment to what degree the two entities are dependent on

hundred and twelve out of 115 adult wild hens killed during the spring and early summer in the vicinity of Madison Wisconsin, between 1943 and 1946, had ovaries that contained ovulated follicles. Although three of the 115 adult wild hens had ovaries which contained no ovulated follicles, the presence of some large follicles suggested that ovulation was imminent. This is evidence that all or nearly all wild hen pheasants lay eggs.

The statistically significant correlations between eggs laid and ovulated follicles found indicates that the later structures can be used to distinguish laying from non-laying hens.

Estimation of eggs laid by experimental pheasants. The correlation coefficient of all the groups treated statistically above has shown that with the exception of Group B, the two variates, number of ovulated follicles found and eggs laid are associated significantly. The remainder of this discussion will be concerned largely with showing by use of the regression treatment to what degree the two entities are dependent on each other and also indirectly how long after ovulation the ovulated follicle can be used to predict the number of eggs laid.

Theoretically if hen pheasants with widely varying egg laying records are killed before any of their ovulated follicles have been completely resorbed, the number of eggs laid would show a perfect correlation with the number of ovulated follicles found in their ovaries. If the eggs laid by such hens were plotted graphically against the ovulated follicles found, the points would fall in a linear regression which would pass through the origin (0, 0).

When the actual points for all hens in Groups A, B, and C, which were killed before January 1, were plotted (Figure

1), they showed a linear regression with only a few deviating points. The points collectively determined a calculated regression line AB, that crossed the Y (Y=eggs found) axis at the nine egg level and not at the origin (0, 0). The two means intersected at Y (42) and X (43), (X=ovulated follicles). The regression coefficient, b, is equal to 0.79, which means that for each ovulated follicle found there is an average of 0.79 egg laid. This is evidence that when pheasants which have laid eggs during the breeding season are collected over a period extending from spring to winter, as were Groups A, B, and C, their ovaries will contain less ovulated follicles than the number of eggs they had actually laid.

The regression line AB can be considered as a moving average determined by the points among which it passes, and the best estimate of eggs laid falls on the regression line. Increasing the size of the sample would result in better precision in estimating eggs laid.

Figure 1 shows that as the number of

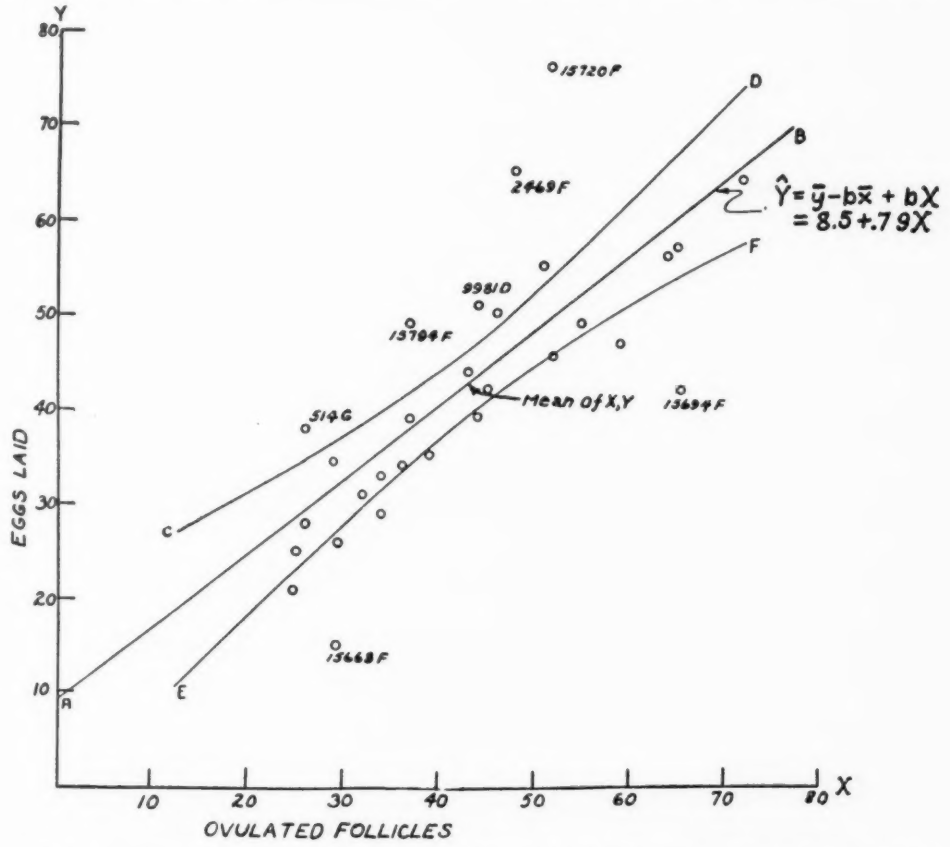

FIG. 1.—Regression of Y on X Ovaries from Group A, B, C hens killed before January 1.

eggs laid by individual hens increased, the number of ovulated follicles found showed a corresponding increase. The distances between the points and the regression line are the deviations from the estimated number of eggs laid for the number of ovulated follicles found in the same ovary. The variable nature of the deviations makes it necessary to determine whether the regression of eggs laid on ovulated follicles is significant.

A highly significant "F" value of 38.0 was obtained when the variance due to regression was compared with residual variance. The variance due to regression is a measure of that part of the total variation due to the relation of ovulated follicles to eggs laid; whereas residual variance is a measure of the deviations of the actual number of eggs laid from the calculated regression line. This highly significant "F" value indicates that ovulated follicles can be used for estimating the number of eggs laid.

The standard error of estimate, or the average deviation of all the points plus and minus distributed about the regression line in Figure 1 is ± 9.2. The standard error of estimate, $s_{y \cdot x}$ in this case can be further defined as the average error incurred in predicting the number of eggs laid from ovulated follicles found in hen pheasants, due to chance variation in sampling. Although the chance variation incurred in predicting eggs laid from ovulated follicles is ± 9.2, the error in predicting eggs for individuals is $s_{y \cdot x}\sqrt{2}$. This means that it would be impossible to compare only two hens for statistical differences in the numbers of eggs laid unless the disparity between the number of ovulated follicles found in each one of the hen's ovaries was at least 27. However, if the mean number of ovulated follicles of groups were compared, the range of accuracy within which it would be possible to say the best estimate is expected to fall 95 per cent of the time would be much smaller, thereby increasing the precision.

Using the points plotted in Figure 1 as a base and letting each point along the regression line represent a group mean, the confidence limits, curves CD and EF, were calculated. Each confidence limit delineates the range of accuracy within which the actual number of "eggs laid" by groups of artificially propagated pheasants as estimated from "mean ovulated follicles found," is expected to fall 95 per cent of the time.

It is believed that the regression rate of ovulated follicles of wild Wisconsin pheasants and the birds in Groups A, B, and C are similar. This is because Wisconsin's wild pheasant population originally developed from artificially propagated birds, and also stock birds continue to be released annually. Therefore, it should be possible to estimate the number of eggs laid by a group of wild hens by tallying the ovulated follicles of each hen, computing the mean and substituting in Figure 1. For example, the best estimate of the average number of eggs laid by a group of wild hens collected at times comparable to the hens in Figure 1 and having a mean of 35 ovulated follicles in their ovaries would be 37. It could also be said that 95 per cent of the time the actual number of eggs laid by this group would be expected to lie between 32 and 40.

It can be seen that the range of accuracy within which eggs laid can be

predicted for groups is much less than that of the value $s_{y \cdot x}\sqrt{2}$ for individuals. It should be pointed out that the data in Figure 1 are directly applicable only when the group of hens analyzed is collected on dates that approximate those of the experimental group and in which the range and mean number of ovulated follicles found is similar.

Seasonal changes. In making estimates of eggs laid from ovulated follicles consideration must also be given to:

(1) Date ovaries are collected.

(2) The range and mean number of ovulated follicles in the ovaries making up the sample that is being analyzed.

In ovaries collected within a period extending from 15 days after the last egg was laid to September 15, it is expected that few, if any, of the ovulated follicles from the current breeding season will have disappeared. In this case the total number of structures classified as ovulated follicles would be expected to equal or almost equal the number of eggs laid. Actually the number of eggs laid significantly exceeded the ovulated follicles found in the ovaries of only 3 out of the 16 hens which were killed before September 15 (Tables 1, 2, and 3). Therefore, application of the data in Figure 1 for the purpose of estimating eggs laid by wild pheasants collected only during the summer and whose mean ovulated follicles is less than 43 would result in estimating more eggs laid than actually was the case. This is apparent since the regression line in Figure 1 is based on hens, some of which were collected during the summer when only a few ovulated follicles have been resorbed, and also on others collected in fall and early winter when probably several and in some cases many, ovulated follicles have completely resorbed.

In order to attain the highest precision possible in estimating eggs laid, using the ovulated follicle as a criterion, an experiment would have be be set up in which groups of hens with known egg-laying records would be collected at different seasons. These groups should be divided into classes based on collections made as follows:

(1) During the summer beginning with 15 days after the last egg was laid, and ending on or before September 15.

(2) In fall, between September 16 and November 15.

(3) Between November 16 and January 1.

(4) During summer, fall, and early winter. This last group could be made up of a combination of the first three.

Each class would then have its own regression line and confidence limits within which the best estimate of eggs laid would fall 95 per cent of the time. It might even be an asset to further subdivide each class into hens having different numbers of ovulated follicles. This would be perfectly logical if wild population varied to the extent that in some years most birds laid only one average size clutch of 15 (this would include a few eggs allowed for random laying), whereas in other years two clutches are laid and possibly in extreme cases three. The word "clutch" as used in this report means average number of eggs laid in nests. Variation in the total number of ovulated follicles found in ovaries could easily occur in periods when the number of eggs laid is influenced by unfavorable weather during hatching seasons, or even in

some cases where such factors as disproportionate sex ratios and population densities might operate to affect reproductive behavior.

In order to detect these variations by using the ovulated follicle criterion, game managers would need data on

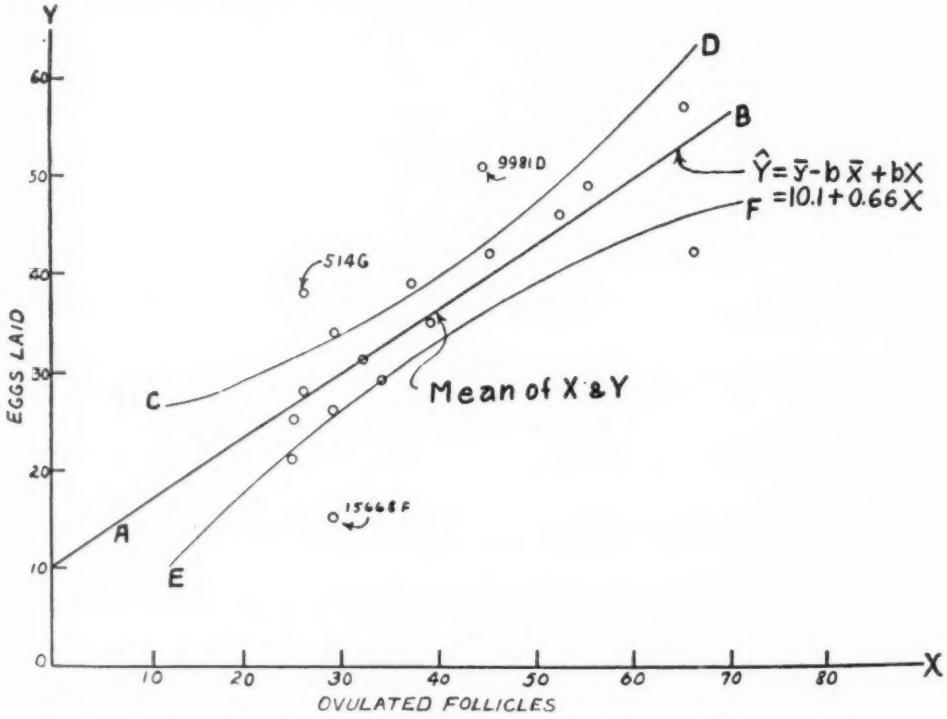

FIG. 2.—Regression of Y on X based on Group A and B hens killed before January 1.

experimental birds that would yield maximum precision in estimating eggs laid. As it stands, the data in Figure 1 alone could be used only to distinguish between groups of hens laying enough eggs to make up one clutch and those laying three. The experimental data reported herein lack the variation in number of ovulated follicles and date of collection to lend themselves to partitioning into the classes suggested above. The best that can be done under the circumstances is to divide the data into two classes other than that shown in Figure 1. The additional classes consist of (1) only the hens in large pens, Groups A and B, and (2) the hens from all three groups whose ovaries contained less than 45 ovulated follicles. Both of these classes were made up only of hens killed before January 1.

The number of eggs laid and the ovulated follicles found for the class containing only Group A and B hens (large pens) is plotted in Figure 2. In general, the difference between the regression line and the confidence limits of Figure 2 and Figure 1 is almost negligible. The value of Figure 2 ap-

pears to be limited to providing further proof that the data from large pens agrees closely with that of the combined groups in Figure 1. This indicates that for practical purposes the data from large pens can be used alone or in combination with Group C (small pens), and that pen sizes did not affect the correlation between ovulated follicles found and eggs laid.

The class of hens (2) whose ovaries contained less than 45 ovulated follicles consisted predominantly of a group that was killed before September 15. Of those killed after September 15 only one showed a significantly greater number of eggs laid than ovulated follicles found. When the ovulated follicles found and eggs laid for each of the hens in (2) were plotted they determined a line of regression that passed through the origin (0, 0) Figure 3. In contrast the regression line in Figure 1 passed through the nine egg level. The regression coefficient here is 1.0; this means that on the average there is one ovulated follicle in the ovary for each egg laid by hens of this category. Since

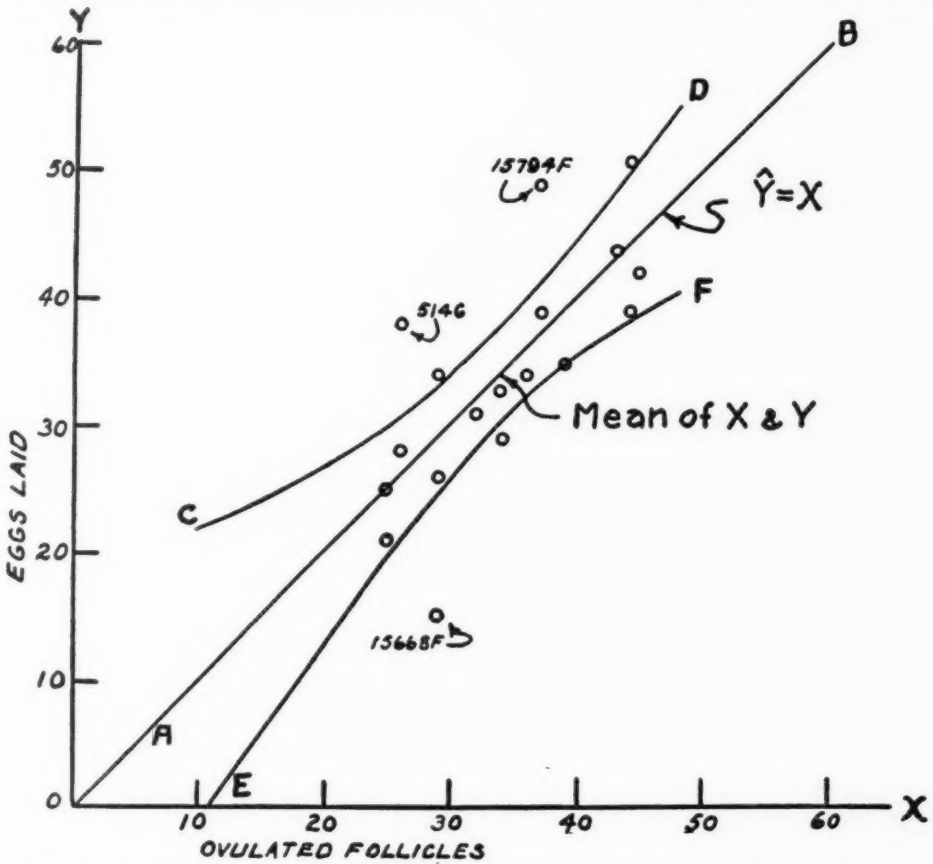

FIG. 3.—Regression of Y on X based on all hens whose ovaries contained less than 45 ovulated follicles.

there were very few ovulated follicles in the ovaries of these birds that had involuted beyond the recognition stage, the regression line and confidence limits calculated for this group could be used to estimate eggs laid by groups of pheasants collected during (1) the summer, (2) early fall, or (3) in summer and early fall. The variance due to regression for this group is highly significant, as it was for the sample analyzed in Figure 1 and Figure 2.

Estimation of eggs laid by wild pheasants. The data shown in Figures 1 and 3 were used to estimate the eggs laid by random samples of two wild populations and to show to what extent it would be possible to detect whether one, two, or three clutches were laid. Random samples of ovaries from two wild populations were collected during the summer in the vicinity of Madison Wisconsin. Six hens from the University of Wisconsin Arboretum were collected between June 13 and June 29, 1943. The mean number of ovulated follicles found in their ovaries was 37. Three of the six hens were still laying at the time they were killed. It would naturally be expected that the set of data to be used to estimate eggs laid in this case would be from Figure 3. For the purpose of comparing results, the data in Figures 1 and 3 are used separately to estimate the eggs laid by these hens.

TABLE 5.—ESTIMATION OF THE NUMBER OF EGGS LAID BY SAMPLES OF TWO WILD PHEASANT POPULATIONS

Population Studied	Data Used to Estimate Eggs Laid	Best Estimate of Eggs Laid	Range Within Which the Best Estimate Occurs 95 Per Cent of the Time
University Arboretum*	Figure 1	38	34–41
	Figure 3	37	34–41
University Bay†	Figure 1	21	13–27
	Figure 3	16	6–24

* The University Arboretum sample consisted of 6 hens whose mean ovulated follicle count was 37.

† The University Bay sample consisted of 15 hens whose mean ovulated follicle count was 15.

The precision obtained by using each set of data is shown in Table 5. Although Figure 3 is most applicable very little precision would be lost by using Figure 1. This is mainly because in this case the mean number of ovulated follicles found in the wild groups approximate that of the experimentals.

The University Bay study was made in 1946 and 15 hens were collected between June 29 and August 29. The mean of the ovulated follicles found was 15. The use of both sets of data separately for predicting the number of eggs laid by the University Bay sample is shown together with the Arboretum data in Table 5. While the range in which the actual number of eggs laid would be expected to fall 95 per cent of

the time is smaller when the data from Figure 1 are used, the most accurate "best estimate" of eggs laid would be obtained by applying Figure 3. The reason the range in which predictions fall is less when Figure 1 is used than when Figure 3 is applied is due primarily to the fact that more individuals are contained in the Figure 1 data. It is apparent that data from either Figures 1 or 3 could be used to show clearly that there is a statistical difference between the eggs laid by the Arboretum and University Bay populations.

The reader might feel that the difference in precision in estimating eggs laid by pheasants collected in the summer using the two sets of data separately is much too slight to be of practical value. If we consider next three hypothetical pheasant populations each laying a different number of eggs the need for the highest precision possible may become more apparent. Let the first hypothetical population resemble the University Bay group in that the ovaries of the hens composing the sample contained a mean of 15 ovulated follicles. Assume that a sample of hens from a second population had ovaries which contained 30 ovulated follicles and a third 45. Each group could represent hens that have laid one, two and three clutches respectively. Assume that all three groups are killed either in summer or early fall at a time when few, if any, of their ovulated follicles have been completely resorbed. The laying of 45 eggs by wild pheasants may be difficult to visualize, but in a subsequent report it will be shown that some wild birds do lay that many eggs during one breeding season. It might be mentioned that the hypothetical group with a mean of 30 pigmented structures does not differ too greatly from the University Arboretum sample, Table 5.

TABLE 6.—ILLUSTRATION OF THE USE OF EXPERIMENTAL DATA IN ESTIMATING EGGS LAID FROM OVULATED FOLLICLES FOUND IN PHEASANT OVARIES

Mean Ovulated Follicles (Hypothetical)	Figure 1		Figure 3	
	Best Estimate	Range	Best Estimate	Range
15	21	13–28	15	6–24
30	33	22–37	30	26–34
45	44	41–48	45	29–52

The range represents the confidence limits within which the best estimate is expected to fall 95 per cent of the time.

The results of the analysis for eggs laid by each of the hypothetical groups are shown in Table 6. Obviously the best estimate of eggs laid would be obtained by using the Figure 3 data but what of the range of accuracy within which the best estimate of eggs laid is expected to fall 95 per cent of the time? Table 6 shows that only the data in Figure 3 can be used to reveal that there is a statistical difference between each one of the three hypothetical populations.

In evaluating the use of the data in Figures 1 and 3 it can be stated that maximum precision in estimating eggs laid by wild pheasants is obtained when

the ovulated follicle tally approximates the mean of the experimental group. On the basis of the results shown for the experimental groups, Figures 1, 2, and 3, in which the mean ovulated follicle count is 34, 38, and 43 respectively, the estimated number of eggs laid for ovaries containing less than 34 and more than 43 structures will be less precise than for ovaries falling between these limits. The ideal criterion would be one which was based on hens collected at the different times suggested for maximum precision in estimating eggs laid and whose ovaries contained individual ovulated follicle counts ranging from 10 to 70.

It is recommended, until more extensive experiments are conducted, that Figure 1 be used to analyze data collected both over a period extending from the time of the last egg to January 1 or for late fall alone and that Figure 3 be used for groups of ovaries collected in summer and early fall. The observer can be guided in estimating eggs laid by examining the range of ovulated follicles found in the different ovaries composing his sample. Samples from different populations containing ovaries whose range of ovulated follicles is small provide evidence that in general the entire population's egg laying rate was probably affected by the same factors. This is illustrated by the University Bay sample in which the range of ovulated follicles for 15 hens was only 12–23, and 9 of these hens had between 12 and 16 ovulated follicles.

Length of time the ovulated follicle can be identified. Two hens were found to retain ovulated follicles with no apparent loss through the winter; 15692F and 15674F in Group B are the examples. The ovaries of some hens, such as 514G in Table 1 and 15720F, seemed to have lost some of their ovulated follicles as early as November 7 following the current breeding season.

A few ovulated follicles were found to have persisted into the following breeding season. Hen 15744F started laying May 7, 1944, and laid at least 48 eggs. After completion of her laying performance she was housed in one of the small pens through the winter. She was allowed to lay three eggs the following spring and then was killed. Her ovary contained 16 ovulated follicles. Retention of ovulated follicles into a subsequent breeding season would cause an error in estimating the number of eggs laid in any one season by hens which were two or more years old.

In general, the data in Tables 1 and 3 show that ovulated follicle remains continue to disappear as time elapses after the last ovulation indicating that resorption is constant. Therefore, it seems probable that most of the ovaries of hens which are two or more years old when killed would not contain more ovulated follicles than the number of eggs laid in their last breeding season. Evidence to support the belief that ovulated follicles developed during one breeding season usually disappear by the beginning of the next is found in the ovaries of some banded wild hens known to be two or more years old at the time of collection from the University of Wisconsin Arboretum. These hens were killed during early spring in 1943 after laying from 1–15 eggs. Examination of their ovaries failed to reveal the presence of ovulated follicles other than those developed in the spring of 1943.

SUMMARY

The egg-laying performance of 38 artificially propagated hen pheasants penned separately were observed and recorded. The hens were divided into three groups. Two groups were confined in large pens simulating wild habitat and the third was quartered in pens of the type used for breeding purposes by the Wisconsin Conservation Department. The hens were killed at selected intervals so that their ovaries would show most of the advance stages of the involuting ovulated follicle. The egg-laying record was then compared with the ovulated follicles found in the ovaries of each hen.

Examination of 93 ovaries from hens that were known to have laid eggs showed that they contained structures which were identified as ovulated follicles whereas the ovaries from more than 100 hens that had not reached the breeding age did not contain similar structures. This led to the conclusion that the remains of ovulated follicles alone can be used to distinguish laying from non-laying hens.

A highly significant correlation was found between the number of ovulated follicles and the number of eggs laid by the hens in the three groups. The hens were killed at varying intervals during the laying period and up to 190 days after the last egg was laid. Hens killed during a period less than 100 days after the last egg was laid showed a higher correlation between ovulated follicles and eggs laid than did those collected at greater intervals. The evidence indicates that the lower correlation for hens killed at intervals greater than 100 days was due to the complete resorption of some of the ovulated follicles.

When the number of ovulated follicles and the number of eggs laid for each hen were plotted graphically the relationship was found to be essentially linear. From this relation was calculated a regression line and confidence limits for estimating the number of eggs laid from ovulated follicles found. The criterion is reliable for the post ovulation period extending from the laying of the last egg during the current breeding season up to December 31 of the same year.

The ovaries of two groups of wild pheasants were examined and the number of ovulated follicles was counted. By applying the results obtained from the experimental hens it was possible to determine that the average number of eggs laid by these two groups of wild hens was significantly different.

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WINTER ACTIVITIES OF WILD TURKEY IN WEST VIRGINIA[1]

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Very little information has been recorded on the winter activities and movements of the eastern wild turkey (*Meleagris gallopavo silvestris* Vieillot). Mosby and Handley (1943) described the breaking up of the family flocks in late winter and the general activities of the wild turkey were reported upon by Bent (1932) and Blakey (1937). Martin, May, and Clarke (1939) briefly recorded some of the winter foods.

Preliminary studies showed that the turkey range in West Virginia coincided for the most part, with the mountain regions of the state. Oak-hickory-pine forest and beech-birch-maple-hemlock forest are the fundamental types of vegetative cover on the range. The oak-hickory-pine occur on shallow soils in areas of reduced rainfall, and at elevations up to about 2,500 and the beech-birch-maple-hemlock forest occur in the higher, rugged mountain regions where the annual rainfall is greater, about 46 inches.

An intensive study of wild turkey activities was started after the 1946 hunting season (October 5 to November 16). Six sample study areas considered representative of the two forest types and known to have a fair wild turkey population were selected. The primary objective was to study the food habits, range, and activities of the birds during inclement weather. White-tail deer, red and gray foxes, bobcats, raccoons, bears, gray squirrels, woodchucks, beavers, cottontails, snowshoe hares, and ruffed grouse live in association on the wild turkey range. The locations of the various sample study areas and their relationship to the general wild turkey range are shown in Figure 1.

KUMBRABOW AREA

Kumbrabow State Forest, located in Randolph County near the center of West Virginia, was established in 1935 and comprises 9,425 acres. The entire area lies at an elevation of about 3,000 feet along the top of the Rich Mountain Range.

From sign, tracks, and sight records the investigator located five flocks in this area during the 1946–47 winter

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with a wintering population of 62 wild turkeys, of which 19 were gobblers and 25 hens. It was impossible to determine definitely the sex composition of the remaining 18, but most of them were hens and young gobblers. The sex ratio varied widely in the various flocks. One flock of 10 was composed entirely of gobblers; however, in most cases several individuals of each sex were found in the wintering groups. During the winter of 1945–46 there was an estimated peak population of 35 birds. Thus the acreage per bird was reduced from 269 that winter to 152 during the winter of 1946–47.

Preliminary observations prior to the hunting season indicated that there were either three or four small flocks ranging on the west side of Kumbrabow. At that time (September 5, 1946) the turkeys were traveling the mountain roads and trails and feeding in the small openings, on the low flats, and on the gentle slopes.

The hunting of wild turkeys is prohibited in Kumbrabow State Forest. However, from personal interviews with hunters and game kill reports, it was determined that at least 17 were killed in the territory adjacent to Kumbrabow. The outside hunting pressure forced the birds to seek areas of less interference and hence the number

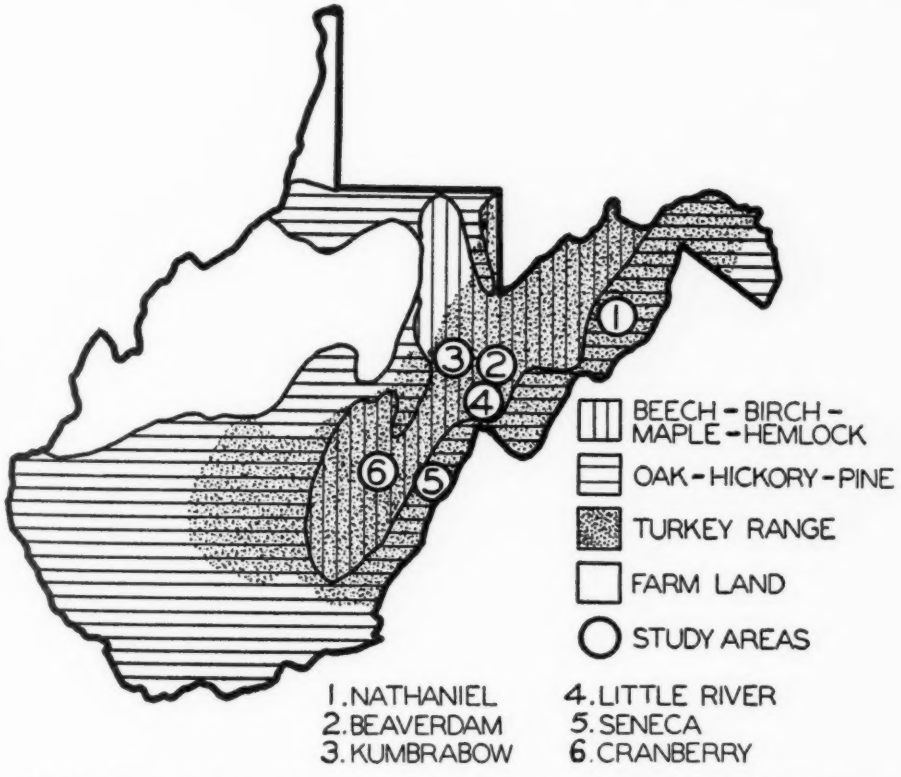

FIG. 1.—Location of cover types and study areas on West Virginia wild turkey range.

of turkeys wintering on the forest was increased.

As winter progressed the birds moved near the center of the area and concentrated on Hamilton Ridge where there was a good crop of beech mast on the flats and feeder ridges. The scarcity of beech mast in other areas was considered the major factor influencing the concentration found along Hamilton Ridge. A few of the turkeys ranged on nearby Mill Ridge during part of the winter where they utilized as range the mature beech (*Fagus grandifolia*), maple (*Acer saccharum*, *A. saccharinum*, and *A. rubrum*), and red oak (*Quercus borealis*) forest on the western slopes.

During mild winter weather the turkeys ranged rather widely. Coves in mature beech stands were used extensively as feeding areas and small, open feeder ridges, forest trails, and old railroad grades provided avenues of travel. With the advent of cold weather and snowstorms in January the daily range was reduced to about three-quarters of a mile radius. Scratchings in snow 12 inches deep were found commonly under beech trees which had produced heavy mast crops (Plate 14, *A*). The turkey range became even more restricted as repeated snowstorms increased the depth of the snow and extended cold weather prevailed throughout February and March. The birds came down from the ridges and started to travel the roads where the snow had become crusted. During such periods of heavy snow cover, the turkey feeding areas were along the streams and around the permanent springs (Plate 14, *B*) where they were able to obtain grit and green feed such as grasses (*Gramineae*), brake fern (*Pteris aquilina*), hepatica (*Hepatica triloba*), violet (*Viola* sp.), and strawberry (*Fragaria americana*). In several places the turkeys scratched out areas adjacent to spring runs searching for beechnuts. During warm periods the birds fed along the exposed road bank where the snow had been blown away or melted off.

Hemlock (*Tsuga canadensis*) and spruce (*Picea rubra*) trees often were chosen as roosting sites. When the turkeys were ranging on the upper beech flats and along the ridge, they roosted in small clumps of spruce near an open but sheltered point. Hemlock groves in small hollows near the stream provided suitable roosting shelter when the snow was deep.

It was noted that during extended periods of soft, deep snow the wild turkeys did considerable flying. When leaving the roost in the morning they would glide to the ground, walk a few yards, and then fly to the feeding area. When the snow was less than 10 inches deep or when the snow was crusted they walked.

An emergency winter feeding area was established in a small cove on the east slope of Hamilton Ridge. At first the turkeys were attracted to this area by the abundant beech mast. The scattering of shelled corn in the area about twice a week continued to hold the various flocks throughout the winter. During the early portion of the winter much of the corn was eaten by whitetail deer, red squirrels, blue jays, and cardinals. The turkeys were obtaining only about 30 per cent. A change in the feeding technique, scattering the corn more and in smaller amounts at each visit, tripled the percentage of corn taken by the turkeys.

The heaviest snowfall of the year (40 inches) occurred on March 4, 1947. Two days later the investigator skied into Kumbrabow and found that the turkeys were feeding extensively on such natural foods as the dried fruit of blackberries (*Rubus allegheniensis*) (Plate 14, *C*), fern, and grass sprouts along the runs. Their tracks indicated they they were investigating every bush and twig for food. Seven birds flushed from the emergency feeding area appeared in excellent condition. Indications were that many of the turkeys were flying directly from the roosting shelter to the feeding grounds and then back to the roost for little sign was found elsewhere. The longest period the turkeys in Kumbrabow remained on the roost without feeding during the winter storms was two days. There was usually a brief cessation of the storm after a couple of days; then they would come off the roost to feed.

Very little effort was expended toward predator control in Kumbrabow State Forest. Fox sign was common over much of the area but the resident population was relatively low when compared with the surrounding territory. The bobcat population was considered rather high. Nevertheless, no evidence of predation on turkeys was found.

BEAVERDAM AREA

Beaverdam Game Refuge is located in the eastern portion of Randolph County with Middle Mountain forming the main mountain range. About 4,700 acres make up the refuge proper with approximately 22,000 acres of surrounding forest land being managed for wildlife. The elevation varies from about 3,000 to 3,800 feet above sea level.

The investigator and H. S. Rhodes, resident refuge manager, compared notes and sight records and determined that the resident winter population consisted of three flocks of wild turkeys totaling 22 birds. An old hen and 11 young of the year made up the largest of the three flocks. Another of seven was composed of five hens and two gobblers. The third flock consisted of two hens and another individual which was thought to be a gobbler.

In autumn the turkeys utilized the open sod areas, brushy edges, open slopes, and coves. All of the birds were widely scattered and their ranges varied considerably from day to day. During the hunting season four small flocks ranged on and off the refuge, depending on the outside hunting pressure. Ten wild turkeys were killed during the hunting season in the areas bordering Beaverdam refuge.

In November, mild and rather warm for the beginning of the winter season, the forest duff was dry and water was scarce in the higher mountains. Then the turkeys were extremely alert and wary and traveled great distances searching for food and water. Close observations on the movements of the flock of three at this time revealed that they had traveled 5.25 miles in five days. Most of the flocks traveled through the forest on trails or along the ridges but they often frequented the open, park-like, mature beech forest. On several occasions turkeys were flushed from the graveled mountain road forming the eastern boundary of the refuge.

Typical winter weather with low temperatures and snow-storms arrived late in December. The first good snow

of the year fell on December 15, 1946 blanketing the mountain regions of West Virginia in two to four inches of snow. On this same day a gobbler was tracked for two and one-half miles through the management area and he did not stop once to feed. His tracks were far apart and it appeared that the gobbler was heading for his preferred winter range as fast as he could walk. In other study areas sign indicated that the turkeys appeared bewildered by the first snowfall and wandered aimlessly about in the snow. As the snowcover became deeper (about 18 inches) the turkeys reduced their daily range and often were found feeding along streams and exposed, wind-blown points along the mountain road. Many times their trails led through the dense greenbrier (*Smilax* sp.) on the ridges and in places one could see where the turkeys had jumped up and fed on the ripe greenbrier fruit. About one-third of the turkey scratchings were located under black cherry (*Prunus serotina*). Dogwood (*Cornus florida, C. amomum,* and *C. alternifolia*) also was an important winter food item but beechnuts were preferred.

As winter progressed and the snow cover increased, the wild turkeys moved towards the emergency winter feeding area which was near a permanent spring located in a sheltered cove. Since the place had natural attraction for turkeys there was little difficulty in getting the birds to come to such a place with water, grit, and the readily available feed. The turkeys fed here regularly and depended upon the artificial feed to a large extent. During very heavy storms they remained close to this area, roosting in the hemlocks along the spring run and flying directly to the protected feeding area. At the height of a blizzard on March 4, 1947 the investigator observed seven wild turkeys feeding and loitering in the area. Mr. Rhodes has reported flushing turkeys from the feeding place almost every time he went to scatter more corn. Red squirrels, gray squirrels, and bluejays obtained a sizeable amount of the turkey feed and a change in the feeding technique here made little difference in the amount of feed taken by the turkeys.

Winter roosting cover in Beaverdam Refuge consisted mainly of hemlock located along the bottoms of streams and runs. On some occasions they roosted in large maple or beech trees on the leeward side of a ridge. Several flocks of turkeys were observed going to roost between 5:00 and 5:30 P.M. when they flew from the emergency winter feeding area directly to the nearby roosting cover. When coming off the roost in the morning the birds sailed a short distance to a small opening, landed, and then walked to a feeding area.

In an extensive predator control program on Beaverdam Refuge, 40 foxes and 2 bobcats were taken in the winter of 1945–46 and 36 foxes were trapped during the 1946–47 season. However, the wild turkeys were harassed to a certain extent as indicated by Mr. Rhode's report of March 19, 1946 of a turkey killed by a fox.

LITTLE RIVER AREA

Little River Refuge, in northern Pocahontas County, has an area of about 9,000 acres and lies at an average elevation of about 3,100 feet along the western slope of the Allegheny Moun-

PLATE 14.—*A*. Turkeys often scratched through deep snow to obtain their food. *B*. Spring runs provided feeding areas during periods of heavy snowcover. *C*. The dried fruit of blackberry was a major winter food in some areas. *D*. Turkeys scratched extensively for beechnuts.

tain. Burner Mountain forms the major physiographic feature of the refuge.

Two flocks of wild turkeys totaling 19 birds were found utilizing the refuge. One flock of 12, of which five were old birds, was located near the summit of Burner Mountain. About half of the other flock were adults. It was not possible to determine the sex ratio of either flock.

In the early winter turkey sign was found along the ridges, trails, and old roads leading along the summit of Burner Mountain. Scratchings were found under beech trees in coves, on gentle slopes, and on narrow flats. A dozen half-hearted scratchings were found on the top of one ridge under several red oak trees. Since there was little red oak mast in the fall of 1946, it was assumed that the turkeys were scratching for and feeding on the old acorns. A cursory examination of some turkey droppings indicated that the turkeys had been feeding on grass, ferns, and the green sprouts of plants. The scarcity of beech mast and other suitable food throughout the entire refuge was believed responsible for the small numbers of wild turkeys. During past seasons of good beech and oak mast approximately 40 to 60 wild turkeys ranged in this area. During 1946–47 the population was much lower. After the severe winter storms in late December the investigator was unable to reach this study area but several reports were received which indicated that the turkeys had left the refuge during the winter.

CRANBERRY AREA

The Cranberry Game Breeding Area is located on the headwaters of Cranberry River in eastern Pocahontas County and includes about 9,069 acres varying in elevation from 3,100 to 4,600 feet above sea level. Surrounding the game breeding area is a management area of 32,175 acres.

Henry Perkins, resident game manager, R. W. Bailey, and the investigator compared notes and from wild turkey sign, tracks in the snow, and sight records determined that 131 turkeys utilized the Cranberry Area during the winter. Eleven flocks varying in number from three to twenty-five were found. Twenty-one were gobblers, 58 were hens, 31 were believed to be hens, and the sex of 21 could not be ascertained.

During the fall months the turkeys utilized openings, roads, and habitat improvement plots. Dusting areas were found in hawthorn (*Crataegus* sp.) thickets, on the top of wind blown hills, along the banks of roads, and at the edges of old rotten logs near forest trails. A little beech mast had fallen and the birds were scratching and feeding in such places. A definite change of range from the open fields to the forests was noted as the beech became available, for the turkeys had ranged widely all fall and were scattered during the hunting season. Those flocks which ranged off the refuge were pursued by hunters and driven to places where they normally would not have been found. Hunting pressure was heavy all around the boundary of the refuge.

With the cold nights and frosts of November, the turkeys moved to the open beech flats to feed, traveling from one feeding area to another along the forest trails. Tracks and sign were common along the creek bottom where they had evidently been collecting grit.

The beech crop was good in most places in Cranberry but the small amount of red oak and black oak acorns was of little value. The thorn apple was heavy in certain, limited areas and the birds frequented these places at times. After several snowfalls the turkeys started to feed around springs and along little runs. Consistently they scratched through the snow for the numerous beechnuts in the protected coves (Plate 14, *D*). In several places deer helped the birds by pawing and breaking through the crusted snow and then the turkeys came to feed. Beech, squirrel corn (*Dicentra canadensis*), fern sprouts, grass sprouts, and snails (*Planorbis* sp.) were eaten.

An interesting observation was made of a large gobbler and two hens on the morning of January 22, 1947. It was cold (about 5°F.) and clear, with the sun shining brightly on 14 inches of snow. The gobbler was doing considerable strutting and guiding the hens in a small opening of a hemlock thicket. He strutted about a half dozen times near the two hens and finally one of the hens postured when the gobbler approached her. The gobbler mounted and treaded her for about 30 seconds; then stood straight, stretched, and ruffled his feathers. The hen stood up, took a few steps and then straightened her feathers The three turkeys continued to walk and mill around in the hemlock thicket for about five minutes before proceeding on up the ridge in single file.

The various flocks in Cranberry continued to range widely throughout the last of January. Snowstorms and cold weather did not restrict their range to any extent but as the snowstorms continued throughout February and March, the flocks reduced their daily range to a radius of about one-half mile. A spring or run, a hemlock or spruce thicket, and a beech flat were usually found in the home range of each flock. The continuous snowcover in Cranberry from January to April averaged about 16 inches. During the periods of deep snow the birds flew or traveled through the trees from their roosting sites to the feeding areas. Lichen, moss, fern, hemlock needles, dried blackberries, greenbrier berries, and rhododendron (*Rhododendron maximum*) leaves were utilized as food. Such a stuffing diet maintained most of the turkeys through the critical periods. Corn and oats were scattered in natural feeding areas during the emergency periods to supplement the maintenance diet. At first the turkeys would not feed on the corn and oats. The resident refuge manager believed that they did not recognize the artificial feed because they had walked over it many times and had not fed. Since all of the flocks in this inaccessible area ranged many miles from agricultural land, it is possible that they may not have become acquainted with the various crops. The addition of raisins to the emergency feeding mixture induced them to sample the feed. Raisins were similar in size, shape, and color to natural food and hence were taken readily. As soon as the snow had cleared the birds left the emergency feeding areas and never returned indicating that the natural food was more attractive than the easily secured artificial feed. On the headwaters of Cranberry River the turkeys fed extensively in an open field where several wind blown points provided clear areas in which grass and green feed could be obtained. Scratchings were found frequently under clumps of

hawthorn growing in the field and they often visited the open water along the stream.

Winter-kill occurred in some places for two birds were found starved to death in the Cranberry basin. More probably succumbed in areas where it was impossible to feed them artificially as is indicated by the data given later concerning the turkeys on Cheat Mountain.

Spruce and hemlock thickets were usually chosen as roosting sites and quite often they returned to the same clump of trees. Hemlock thickets along the streams were preferred but roosts were found in deciduous trees on two instances. At no time was any evidence found to indicate that the turkeys had burrowed into the snow like grouse. However, the turkeys roosted close to the ground during snowstorms that were accompanied by high winds. Four days was the longest period the observer knew of turkeys remaining on the roost in a bad storm.

Great horned owls, red and gray foxes, and bobcats were common predators in the Cranberry area but the evidence of only one turkey kill by a red fox was found. Fox tracks were numerous, but especially so where turkey and cottontail tracks were common. Evidence indicated that the foxes were hunting the cottontails at night and the turkeys during the day.

NATHANIEL MOUNTAIN AREA

Nathaniel Mountain Refuge, comprising about 8,594 acres, is located in the southern portion of Hampshire County and includes most of Nathaniel Mountain, which is at an average elevation of 2,500 feet.

Raymond Hawse, refuge manager, assisted the writer in determining the winter turkey population. Three flocks were known to range in this area. Prior to the hunting season there was a total of 55 birds in three flocks of 15, 18, and 22 respectively. After the hunting season there was a total of 18 birds forming the wintering population. Four were gobblers, nine were hens, and the sex of the others was not determined. Hunting pressure on opening day was heavy throughout Hampshire County and especially so around Nathaniel Refuge as evidenced by seven hunters passing a check point in an hour. The number of hunters varied with the locality and hunting conditions but in general they had a tendency to concentrate in areas where flocks had been flushed and scattered. One of the three flocks was scattered widely, another was fairly intact, and the third group ranged inside the refuge the greater part of the season. Nevertheless, the hunter's take in this study area was approximately 70 per cent of the pre-season population.

Warm weather and little precipitation during November and December caused many of the mountain springs and runs to become dry. The availability of water in such dry periods affected the movements of the turkeys for they came down from the ridges and traveled along the larger runs where food and water were easier to obtain. Such a movement quite often brought the daily range of the birds in contact with people who might poach upon them. Scrub oak (*Q. ilicifolia*) thickets provided escape cover and feeding areas. Maple seeds were utilized where abundant but did not constitute an important fall food. Some red oak acorns and wild grape (*Vitis labrusca*) were available

but the major food item at this time was dogwood, as scratchings were noted under practically all dogwood trees. Until the killing frosts in the middle of November, they frequented the fields to feed on insects. The food condition was considered poor over the entire range in the oak-hickory-pine forest. Those birds examined in hunter's bags towards the end of the season were thin indicating the poor food conditions as early as the hunting season. The continuing mild weather was definitely on the credit side of the ledger in maintaining the birds. In their search for food the turkeys traveled great distances with a resulting daily cruising radius of about 4 miles. The family group was scattered widely during most of the day but this condition was changed somewhat by the end of November when the limited fall rains started more springs to flow and cold weather reduced evaporation. The turkeys now were traveling in close groups feeding in the valleys and coves. Food continued to be scarce and the weather became colder in December. At times they even resorted to feeding on year-old hickory nuts and acorns but dogwood, scrub oak acorns, and a little wild grape furnished the bulk of the diet. Deer and squirrels were competing directly with the turkeys for the scrub oak acrons and had reduced the supply to unimportance.

Several snowstorms in late December and through January restricted the range. For the most part, the flocks were utilizing the oak-pine (*Q. alba*, *Pinus rigida*, and *P. virginiana*) coves on the warm exposures and feeding on anything that might be palatable such as old hickory nuts, old acorns, witch-hazel, maple, and greens along runs. High winds coupled with succeeding snow and sleet storms broke down the old grape vines, making the abundant crop of grape available. Thus throughout the entire period when the snow was the deepest and the weather was the worst, grape was accessible and the turkeys had excellent fare. Spring came early and no instances of winter-kill were known.

Virginia pine and pitch pine thickets about 40 years old provided suitable roosting sites throughout the winter. There was not an abundance of suitable roosting sites so the turkeys returned and used the same thickets many times. The pine patches utilized as roosts were found along ridges, on the points of ridges, and in the coves. Those particular roosting sites which were preferred were located in sheltered coves, in tall, crowded thickets, and with a dense understory of scrub oak.

Only a small amount of predator control was undertaken and little trapping was carried on by the residents as the fur prices were low all season. The sign of red foxes, gray foxes, and bobcats was abundant over the entire area but only one predator kill of a wild turkey was found.

SENECA AREA

This study area in central Pocahontas County comprised about half of Seneca State Forest and consisted of approximately 5,000 acres. Big Thorny and Little Thorny Mountains were the main physiographic features of the area, with an average elevation of about 3,000 feet.

Prior to the hunting season between 50 and 70 birds were ranging in the area. Controlled hunting was permitted

for only ruffed grouse, squirrels, and deer but the presence of many hunters in the shooting area caused the turkeys to scatter and leave the refuge resulting in a heavy turkey kill in the surrounding territory.

After several attempts in December to locate turkeys again using the area, it was not until January 10, 1947 that a flock of 11 was flushed on Big Thorny Mountain. Five were adults and the remainder were young of the year. Unfortunately the sex ratio could not be determined. These birds had been feeding on hickory nuts, last year's red and white oak acorns, and sugar maple seeds. Apparently they had fed extensively on the maple for most of the scratchings were under maple trees and the seeds were plentiful. Suitable turkey food was scarce throughout the entire forest and the high population of deer and squirrels in the area made it difficult for the turkeys to find sufficient food. About 15 inches of snow covered the ground on February 26, 1947 when R. W. Bailey flushed seven to nine turkeys from the slopes of a ravine where they had been feeding regularly for several days. Sign indicated that they had been in this ravine since early morning but no scratchings were in evidence. Seemingly the birds had not fed and appeared to be in a weakened condition. All of the flock appeared to be hens but one gobbler was known to range with them. Corn was shelled and scattered in the area in an attempt to provide food during the critical period. Two days later the same area was checked and it was found that the birds had flown in or had traveled through the trees to the feeding area and most of the corn had been eaten.

A story of the actions of a hen traveling along a road near the edge of Seneca State Forest was clearly written in the snow on March 4, 1947. R. W. Bailey reported that the bird had investigated every object, bit of weed, or grass protruding above the snow for she had pecked at Canada thistle (*Cirsium arvense*), seedling pitch pine, and dried blackberries. In general the same places were visited on the first and return trips. Where small ravines crossed the road, running water had melted away the snow and the turkey methodically visited each of these, scratching a little in one or two.

Close observations of the turkeys in Seneca showed that all of the birds were gaunt, haggard, and weak. No starved turkeys were found in the study area but one was reported from Michael Mountain about six miles east. It was believed that two or three birds might have starved in the study area as the total numbers in the flock was correspondingly less after the critical period.

Suitable roosting shelter was not available during the storms. Some roosting sites were located in mature maple and hickory in sheltered coves, but the preferred roosting sites in clumps of tall pine in protected areas were scarce. Virginia and pitch pine are coming in rapidly over most of the forest and in the next twenty years there should be plenty of suitable roosting shelter.

No attempt was made to control the predator population in the study area but no predation on turkeys was found even when the birds were in a weakened condition during the storms.

DISCUSSION

The general winter conditions in West Virginia in 1946–47 were ex-

tremely difficult for turkeys to cope with. The food supply was poor over most of the state for the red oak, white oak, and black oak (*Q. velutina*) had produced a very small mast crop. The beech crop was good in most places but characteristically "spotty." In areas where the beech mast was considered good only one tree in eight was loaded. Blackberry canes produced many berries but few ripened because of the continuing cool, dry fall. Fortunately some were persistent and provided a little winter food. Black cherry, dogwood, witch-hazel, and greenbrier produced an abundant supply of food and no doubt were important in maintaining the turkeys during the inclement weather. Mild weather prevailed during the early part of the winter but from the middle of January to the first part of April (about 81 days) the entire mountain region was covered with snow from two to fifty-two inches deep. The combination of extended severe weather and a poor food supply created critical areas where winter-kill was common. By means of frequent censuses and actually finding the dead birds, it was determined that from 50 to 80 per cent of the turkeys succumbed in the Shaver's Fork area on Cheat Mountain. In other parts of the beech-birch-maple-hemlock forest where the turkeys could not obtain emergency winter feed, post-winter check censuses revealed that the flocks were reduced about 30 per cent. This condition was not prevalent in the oak-hickory-pine forest because the snow did not remain on the ground for long periods. All of the turkeys found dead were young of the year and females. The extreme emaciation of all of the dead birds plus the noticeable lack of available food indicated that they had starved to death. Three of four birds examined from one area had quantities of grit, gravel, fern, hemlock, and spruce needles in their gizzards or crops. In one the crop contained a red spruce twig and the remainder of the digestive tract was empty. It was estimated that the birds had lost from 30 to 50 per cent of their fall weight.

MANAGEMENT

Recommendations which the investigator believes will improve the winter carrying capacity of the wild turkey range in West Virginia are the following: (1) Make natural food plantings of blackberry, greenbrier, holly (*Ilex verticillata, I. monticola,* and *I. collina*), dogwood, hazelnut (*Corylus americana, C. cornuta*), and wild grape along the edges of mountain roads, forest trails, old railroad grades, abandoned fields, and spring runs to supply persistent winter feed. (2) Open up the forest canopy along the railroad grades and forest trails to give the shrubs an opportunity to spread. (3) Plant Virginia, pitch, and red pine in one-half to one acre plots in protected coves on southern exposures for future winter roosting shelter. (4) Release wild grape vines that have climbed high into trees by falling the trees. Then trim, prune, and open up the surrounding forest. (5) Clean out all permanent springs. On the spring runs make a series of small, terraced, log dams to impound pools of water to provide an adequate water supply during all seasons and to increase the available feeding areas during periods of snowfall. (6) Practice emergency winter feeding following two

weeks of continuous snowcover over ten inches in depth. Shelled corn, buckwheat, oats, raisins and straw should be scattered widely in natural feeding areas along streams and around springs for maximum turkey utilization. It is best to clear the snow away from an area before scattering the feed and trails broken through the snow help the turkeys locate the emergency feeding areas.

SUMMARY

1. Very little detailed information has been reported relative to the activities of the eastern wild turkey under severe winter conditions. Six sample study areas considered representative of the oak-hickory-pine, and the beech-birch-maple-hemlock forest with a fair wild turkey population were selected.

2. The known sex ratio in 21 of the flocks was 51 males: 100 females.

3. As would be expected, the hunting pressure directly affected the winter population of turkeys.

4. The daily range was reduced markedly by deep snows. At times the birds moved just between the roosting sites and the feeding areas. During the periods of deep, soft snow the turkeys traveled through the trees or flew short distances.

5. Turkeys commonly scratched through snow 12 inches deep to obtain food.

6. Permanent spring runs were found to be important in determining the winter carrying capacity of a range.

7. Grass, fern, hepatica, violet, blackberry, strawberry, wild grape, greenbrier, dogwood, black cherry, maple, beech, and oak were utilized as winter food.

8. Emergency winter feeding aided in maintaining the turkey flocks.

9. Winter-kill in certain localities was high (estimated 30 to 80 per cent). None of the dead birds found and examined during the winter had succumbed from lack of grit. All had apparently starved to death.

10. A few turkeys were taken by predators.

11. A management program to improve the winter carrying capacity of the wild turkey range in West Virginia should include: natural food plantings, spring and stream improvement, and limited winter feeding.

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THE MANAGEMENT OF GEORGIA DEER

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The influence of human meddling with nature's stocking plan is perhaps nowhere else so noticeable as in the deer herds of Georgia. In past years the State had been plentifully supplied with the native Virginia white-tail deer, *Odocoileus virginianus virginianus*, but with the settlement of the State, especially during the years between 1790 and 1835 their range gradually decreased and the numbers of herds decreased accordingly. Eventually, from a condition of well-scattered herds, the deer populations were isolated from each other and formed concentrated populations. Herds were effectively separated from other herds by wide barriers of agricultural areas and centers of populations.

Fortunately for the deer, there were present throughout the entire State certain conservation-minded individuals, selfish to be sure, who posted their land and rigidly patrolled these areas against the hunter. In the southern half of the State, including the lower portion of the Piedmont and most of the coastal plains, these areas of refuge were on the large plantations. Many of these plantations are in existence today and are still used as game refuges.

The "refuges" of northern Georgia were comprised of the large industrial holdings, usually the kaolin and marble industries, and were fairly well-regulated as far as techniques of that day were concerned. The northern areas averaged 30,000 acres while the southern areas averaged 10,000 acres in size.

These refuges were neither inviolate sanctuaries, nor were they areas especially set aside for the preservation of the deer. Instead, they were hunted annually by the owners and, except for protection, the deer were left to fend for themselves. No efforts toward furnishing food or cover were made, nor were these refuges posted or fenced.

The judiciary of the State, and even the colonial government, realized that there was a need for fundamental game conservation, and in 1773 a meeting of the Colonial Governing Board ruled that anyone found hunting deer with a light was to receive thirty lashes on the back, "well-laid." This was only the beginning of the usual gamut of law-making found in all states. The initial laws for game-protection were as follows:

1849: First legal hunting season for deer.

1857: First "buck" law.

1859: First county entirely closed for hunting.

1874: First State Game Preserve.

1890: State hunting seasons established.

1893: Prohibition of selling of game.

1903: Establishment of Game Rangers.

Generally speaking, there are three types of deer, classified according to their habitat: The "North Georgia deer"; the "South Georgia deer," and the "Coastal Island deer." The reason for such a classification is based on the past "management" practices of the landowners.

The South Georgia deer are a result

of plantation management and are the only true Virginia white-tail found in Georgia; a result of little restocking of outside deer. These deer remain in the dense river bottoms of South Georgia and furnish little pleasure to the hunting public. It was in this respect that the plantation system was not satisfactory until very recent times. These deer have been shot only by the plantation owners and their friends. In the past no effort was made to set aside areas of cover but rather all lands not utilized for agriculture were considered game land. As a result of recent improvements in management practices these plantations are incorporating plans for deer into their plans for the future. Certain portions of the plantations have been left in an undeveloped condition, thereby furnishing ample cover. Food strips are planted and access to winter cattle-pasture is provided so that food is no longer a problem. Protection is organized to such an extent that three or four plantations will organize a patrol force deputized by the State but paid from private funds.

The results of such practices are overpopulation and the inevitable crop damage, just now beginning to appear. The natural foods are present in sufficient quantities, but as a result of the pampering received, the deer are now on a true southern diet of turnip greens, tobacco, peas and cut-corn. These animals can no longer be considered as truly wild. Predators have been eliminated and the deer are so accustomed to seeing humans that they are no longer a sporting animal.

The above conditions are true only for South Georgia deer.

The North Georgia deer are different in habits and ancestry. North Georgia has been the melting-pot for many forms of North American deer. At one time or another, there have been brought into the State deer from Texas, Montana, Wisconsin, Mississippi, Michigan—and even Europe. The greatest management problem attached to the northern herds is protection; food and cover have always been plentiful, but the independent attitude of Georgia mountaineers has always provided venison for the family. It is in this area that the first organized management efforts were made.

With the establishment of the Chattahoochee National Forest, game management became an actuality, portions of the forest going into the Blue Ridge Game Management Area under the direction of the State Game and Fish Commission, which acted as a nucleus for expanding activities in the mountains.

In 1941, the first organized deer hunt was held in the Management Area under the direction of the Forest Service and in 1945, the State actively participated in these hunts. Unfortunately, there are no detailed reports on the first four years of hunting, but since that time there have been complete records kept as to the estimated age, weight and points on the deer killed.

The organization of these hunts is on a cooperative basis between the United States Forest Service and the State Game and Fish Commission. All people desiring to hunt fill out applications and send them in to the State for the eventual drawing. The hunt is limited to 500 individuals, each of the hunters paying a five dollar fee. The revenue is shared equally by the Forest Service and the State.

The original list of 500 is then divided into two groups, the first group of 250 hunts the area during the first three days; the second group hunts during the last three days.

Each list is divided into sixteen sub-

During the season of 1947, it was conservatively estimated that each deer killed meant an income of $113.00 to the State.

Figure 1 shows the correlation between the points and weight of the

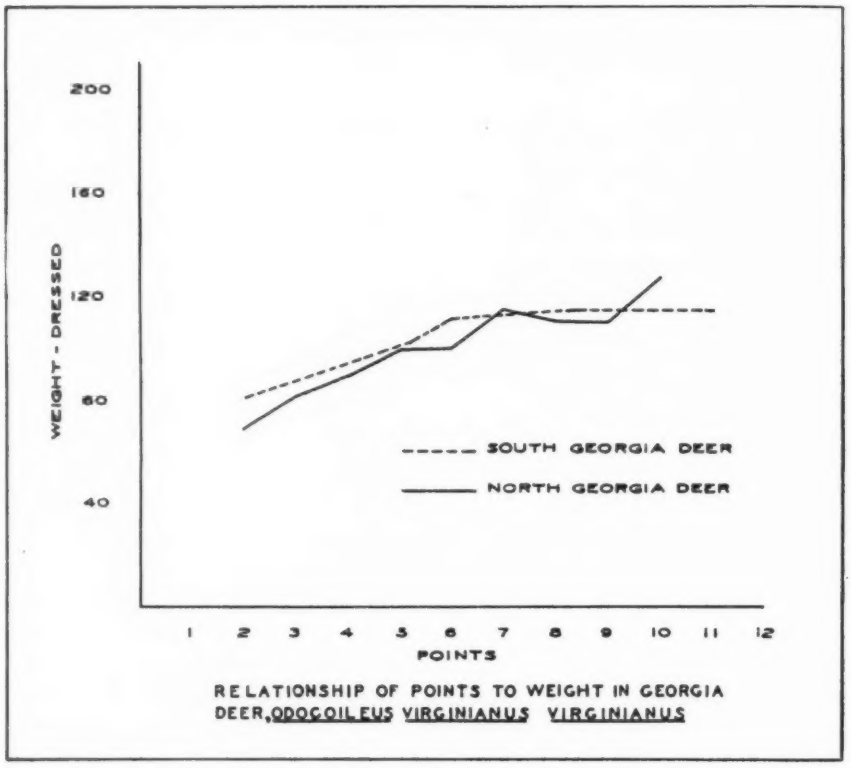

FIG. 1.—Relationship of points to weight in Georgia deer, *Odocoileus virginianus virginianus*.

groups, each of these being assigned a specific area or compartment in which to hunt. Each hunter must report to the area checking station upon entering and leaving the area each day. Upon killing a deer, he must bring the animal to the checking station for weighing and to be checked out of the area.

northern deer and a comparison of the same data on the more southern deer. From this information it would appear that the southern deer is slightly heavier than its northern relative, a condition believed to be due to the differences in the diet of the animals.

The third and last "type" of deer is

the Coastal Island deer. This population has been exposed to a starvation diet, over-population, no hunting pressure, and importation of species from other areas. One island upon which there is no trespassing of any kind supports a population of approximately 200 deer; 25 pure white animals and 17 entirely black animals being counted in separate groups. This island is five miles long and two miles wide. From this survey, made by air, it appears that they were extremely thin and undernourished. This is, of course, an extreme condition, but it is believed that these islands support the only animals in Georgia affected by a food shortage.

The most important problem of administration at the present time involves the use of dogs for driving the deer.

The nature of the deer habitat makes "dogging" imperative in the swamps of the southern counties. To hunt by other methods in these swamps means that the animals will retreat into areas inaccessible to man, with the result that few kills will be made.

In North Georgia the situation is quite different. The hunting in this area is typically upland game hunting. Widely separated, mature trees, with little or no underbrush, increases the visibility to 200 yards in these typical southern Appalachian hardwoods. Dogging deer under such conditions is not considered as a truly sporting gesture, but it is also very doubtful if running by dogs does much damage if the animals are not shot. In the absence of predators it may even furnish predation necessary for the welfare of the deer.

In addition to the question of dogging, there has always been great pressure brought to bear by the sportsmen of the State in the stocking of certain areas, either for the use of the general public, or by private individuals. These demands have been met when the funds have become available. In the case of private individuals, the cost is paid by the person desiring the deer, and the transportation is furnished by the State.

In many cases, through the benefit of Pittman-Robertson funds, the State has cooperated with hunting clubs in the stocking of cooperative refuges, managed by the State, upon written contract that these areas will not be hunted either by the club or by the public until such time that the department believes the herd has increased to numbers where it can stand the pressure of hunting. In all such areas established to date, it has been agreed that when opened to hunting, they will be administered on a controlled-hunt basis, open to the public, with special rights to the private cooperators.

There are two distinct problems of management in the northern and southern sections of Georgia. The majority of the areas in the mountains of the north are thickly covered with mature, upper-story timber. This means that many areas are not furnishing the food for the resident herds which they are capable of furnishing. It is felt that in the near future a system of "patch" logging will be initiated, managed by the State Game and Fish Commission, so that these small patches will be clear-cut, and maintained in the reproductive stage to provide a more diversified diet.

In the south, the creating and maintaining of brush "trailways" is being considered by which there is made

available a means of passage from one isolated area to another. At the present time, there are many farms that have worked to the very edge of some of the principal watercourses throughout the southern portion of the State, but a number of farmers and ranchers have already agreed to allow the land to return to brush, thereby controlling erosion and aiding the animals in their movements from one area to another.

The future of deer management in Georgia is been approached from the following directions:

1. Trapping and redistribution of native stock under Pittman-Robertson activities;

2. More controlled hunts in management areas recently acquired or being acquired in conjunction with the Federal Aid Program;

3. Research and investigation of our native deer as to their food habits and the ecology of the species;

4. Continued and increased effort in the fields of public education;

5. Increased cooperation between private landowners for the establishment of inviolate sanctuaries in some cases and excess animal trapping in others.

With the developments in the northern states as a guide and with what is believed to be a sound program for the future, it is believed that the hunting public in Georgia will be furnished more and more opportunities for deer hunting without the disastrous fluctuations experienced in our northern states.

BRIEFER ARTICLES

A METHOD FOR CORRECTING KILL ESTIMATES FROM WATERFOWL BANDED DURING THE HUNTING SEASON

One common reason for banding waterfowl on their nesting grounds, rather than during the autumn migration, is the greater ease and certainty of estimating hunting pressure from the numbers of bands reported from shot birds. Although, in the past, most waterfowl have been banded during the autumn migration, it was understood that the numbers of bands reported by hunters shooting in the same season were less complete than for birds banded before hunting begins. In the case of a duck such as the mallard, which nests in the Prairie Provinces of Canada and winters on the Gulf Coast, birds banded after the opening of fall shooting have already run part of the gantlet of

TABLE 1.—SUMMARY OF REPORTS ON MALLARDS SHOT THE SAME SEASON THEY WERE BANDED

	Adult ♂♂	Juvenile ♂♂	Adult ♀♀	Juvenile ♀♀	Unaged ♀♀		Seasonal Totals	
1940								
No. Banded	84	183	1	16	199		483	
No. Bands Rep.	4	16	—	1	18		39	
						% Rep.	8.1	
1941								*1940–43*
No. Banded	79	116	9	23	85		312	5,686
No. Bands Rep.	4	5	—	6	1		16	361
						% Rep.	5.1	6.3
1942								
No. Banded	350	778	17	106	631		1,882	
No. Bands Rep.	28	68	—	11	42		149	
						% Rep.	7.9	
1943								
No. Banded	632	1,290	14	52	1,021		3,009	
No. Bands Rep.	24	66	1	7	59		157	
						% Rep.	5.2	
1944								*1944–45*
No. Banded	330	637	6	200	605		1,778	4,065
No. Bands Rep.	37	67	3	21	37		165	363
						% Rep.	9.3	8.9
1945								
No. Banded	673	819	8	92	695		2,287	
No. Bands Rep.	43	83	2	10	60		198	
						% Rep.	8.7	
Total No. Banded	2,148	3,823	55	489	3,236			
No. Bands Rep.	140	305	6	56	217			
Per Cent Rep.	6.5	8.0	10.9	11.5	6.7			

Total	All ♂♂	All ♀♀
No. Banded	5,971	3,780
No. Bands Reported	445	279
Per Cent Reported	7.5	7.4

hunters. The problem is to find some method for adjusting the percentages of bands returned from intermediate banding stations so that they can be related to the total season's kill.

In a report by Mann, Thompson, and Jedlica (1947) on the work of the McGinnis Slough banding station in Cook County, Illinois, these authors included a comparison of the percentage of birds reported as shot in the same season for several species. A breakdown of these percentages for the mallard is shown in Table 1. At that time, for want of better information, it was supposed that, in the mallard, about half of the season's kill had been made before the midpoint of the autumn banding program was reached (November 5). It was also guessed that hunters reported the bands from about half of the birds they killed. This indicated that the observed percentages should be multiplied by about four to correct for these two sources of error.

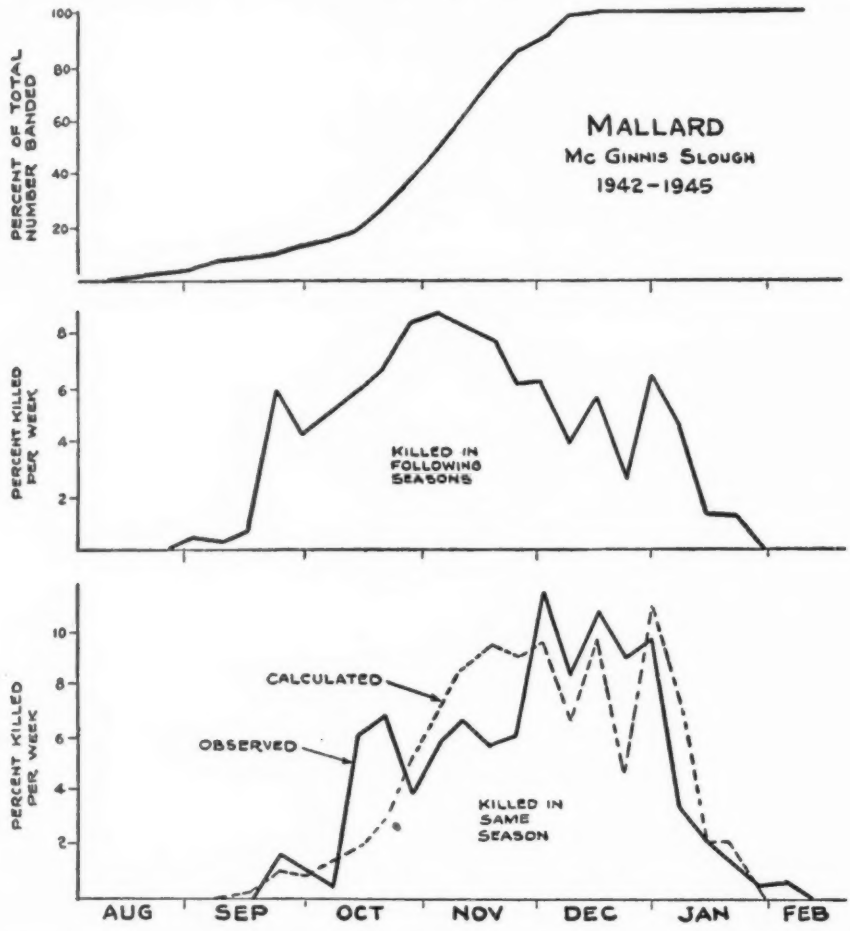

FIG. 1.—Graphic presentation of banding, kills, and relation of observed to calculated kills.

Although the percentage of bands reported by hunters is still open to question, a method has been found for estimating the fraction of the kill missed due to banding during the hunting season. The manner in which this

correction is made will be shown here, using the mallard data from the McGinnis Slough banding station.

Since the timing of the fall migration of other species is usually different from that of the mallard, and since the timing of the fall migration of the mallard is different at different stations, a computed correction can be used only for one species at one station.

The average season's progress of mallard banding at McGinnis Slough, as taken from Mann (1943, 1944), and Mann, Thompson, and Jedlica (1947) on the work of this station is shown in Table 2 and Figure 1. Data from the autumns of 1942, 1943, 1944 and 1945 have been used because they represented full seasons of banding with six traps and a standard procedure from early August until the final freeze-up early in December.

The reported kills of mallards banded here during these autumns, 1942–1945, were separated into (a) those killed the same season they were banded and (b) those killed in following years; and tabulated by weeks. There was a total of 1,121 such reports up to November 1946 which gave the date of kill accurately. These tabulations are also shown in Table 2.

TABLE 2.—SEASONAL DISTRIBUTION OF BANDING AND OF REPORTED KILLS OF MALLARDS

Week Beginning	Total Number Banded to Date 1942–45	*A* Per Cent of Total Number Banded to Date	Number Reported Killed in Following Seasons	*B* Per Cent Reported Killed in Following Seasons	*A* × *B* Per Cent	Number Reported Killed in Same Season
Aug. 2	48	*0.5*	—	—	—	—
" 9	120	*1.3*	—	—	—	—
" 16	198	*2.2*	—	—	—	—
" 23	289	*3.2*	—	—	—	—
" 30	392	*4.4*	2	*0.4*	*0.0*	—
Sept. 6	614	*6.9*	1	*0.2*	*0.0*	—
" 13	764	*8.5*	4	*0.8*	*0.1*	—
" 20	911	*10.2*	31	*6.0*	*0.6*	10
" 27	1,160	*13.0*	22	*4.2*	*0.5*	6
Oct. 4	1,354	*15.1*	26	*5.0*	*0.8*	2
" 11	1,658	*18.5*	30	*5.8*	*1.1*	36
" 18	2,393	*26.7*	35	*6.7*	*1.8*	41
" 25	3,278	*36.6*	44	*8.5*	*3.1*	22
Nov. 1	4,305	*48.1*	46	*8.8*	*4.2*	34
" 8	5,496	*61.4*	43	*8.3*	*5.1*	40
" 15	6,531	*72.9*	40	*7.7*	*5.6*	34
" 22	7,642	*85.3*	32	*6.2*	*5.3*	36
" 29	8,167	*91.2*	32	*6.2*	*5.7*	69
Dec. 6	8,861	*98.9*	20	*3.8*	*3.8*	49
" 13	8,956	*100.0*	29	*5.6*	*5.6*	65
" 20	8,956	*100.0*	13	*2.5*	*2.5*	53
" 27	8,956	*100.0*	34	*6.5*	*6.5*	58
Jan. 4	8,956	*100.0*	24	*4.6*	*4.6*	21
" 11	8,956	*100.0*	6	*1.2*	*1.2*	12
" 18	8,956	*100.0*	6	*1.2*	*1.2*	8
" 25	8,956	*100.0*	—	—	—	2
Feb. 1	8,956	*100.0*	—	—	—	3
Total	8,956	*100*	520	*100*	*59.3*	601
Mean date			Nov. 14		Nov. 30	Nov. 28

The time distribution of mallards reported killed in following seasons is, presumably, unaffected by the fact that they were originally banded during the hunting season, and is representative of the entire area from which this banding station draws its mallards. The percentage distribution of these birds is also given in Table 2 and Figure 1. Assuming that this is true, the time distribution of the kill in the same season can be computed by multiplying the percentage already banded in each week (column *A*) by the per cent reported shot in following seasons in that same week (column *B*). These product percentages are shown in column $A \times B$. The sum of these product percentages for the different weeks of the hunting season is 59.3. This means that the kill of mallards in the same season, after having been banded at McGinnis Slough, is 59.3 per cent as great as if those same birds had been banded before the start of the hunting season. Therefore, the disadvantage of banding mallards at McGinnis Slough during the hunting season can be corrected by multiplying the percentages in Table 1 by 100/59.3, or 1.69.

As a check, this computed time distribution can be compared with the actual observed time distribution in the same season of shooting which is also given in Table 2. These two distributions are drawn to the same scale and superimposed in Figure 1. The mean dates of the two differ by only two days.

This check leads us to believe that this is a valid method for correcting kill estimates and may allow the use of a large volume of data, already in existence, for such purposes.—DAVID H. THOMPSON and JOHN JEDLICKA, *Forest Preserve District of Cook County, River Forest, Illinois.*

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SAFFLOWER AS A WINTER GAME BIRD FOOD

During the past two years experimental game food plantings have been made in a number of ways to test the value of safflower as a winter pheasant and Hungarian partridge food in northern Idaho.

Safflower (*Carthamus tinctorius* L., family Asteraceae) was introduced to this country from India and Egypt where it has been cultivated for many years as an oil-seed crop and a source of red dye derived from the flowers. The plant is an annual herb growing to a height of one to four feet. Two distinct varieties are recognized: *typicus*, a spiny variety, and *inermis*, which is spineless. Safflower plants have a long taproot system which enables them to resist droughts. The stems are rigid and very sturdy, resisting wind, hail, and even heavy winter snows. The seeds are born in a tight head which holds the seed even through heavy winter snows. Seeds of safflower look like sunflower seeds, but are one-third as large. In the United States safflower has been grown largely on an experimental basis in the northern great plains and in some western states.

During the first season that safflower was grown for game birds in northern Idaho, both ring-necked pheasants and Hungarian partridge readily adapted themselves to feeding on safflower. One group of pheasants lived in an experimental area and utilized safflower heavily during January and February, the period of heavy snow. Corn and safflower were the foods most readily available during heavy snow, and the safflower, grown

in the same food patch with corn, was consumed first. It apparently rates high in palatability. Penned pheasants learn to eat safflower quickly after it is first offered. In a two-month experimental feeding trial, four penned pheasants were fed a diet of safflower supplemented only by occasional apples or green vegetation. This trial lasted from mid-December to mid-February. Pheasants suffered no serious weight losses and were maintained in good condition on this diet.

During the second winter (1947–1948) of safflower trials, Hungarian partridges, as well as ring-necked pheasants, were found wintering in areas near safflower and utilizing the seed.

The nutritive value of safflower has been demonstrated through livestock feeding experiments in the United States and Germany. Safflower seed cake or meal may be used as a protein-rich concentrate in the same way that cottonseed, linseed, or soy bean meals are used. The composition of safflower press cake from whole seed as given by Rabak (U.S.D.A. Cir. 366, 1935) is shown in Table 1.

TABLE 1.—PER CENT COMPOSITION OF SAFFLOWER PRESS CAKE FROM WHOLE SEED

Moisture	Ash	Protein	Crude Fiber	Nitrogen-Free Extract	Ether Extract (fat)
4.10	*2.90*	*19.20*	*42.60*	*25.40*	*5.80*

Safflower has been suggested as both a dry land and an irrigated crop. In northern Idaho, good results have been obtained seeding in late May or early June as a dry land crop. Seeding in rows with a hand seeder has been uniformly successful. Seeds were planted 1½ inches deep and about one to two inches apart. From the practical standpoint, broadcast seeding in conjunction with grain drilling has the best possibilities. After the ground is ready for drilling to peas, oats, or wheat, the safflower is broadcast by hand in front of the drill. Drilling adequately covers the seed. There should be no time lapse between broadcasting and drilling since small birds clean up the seed quickly. Harrowing a well-prepared seed bed is also a practical means of covering safflower seed. Broadcasting at a rate of about 25 pounds per acre is recommended for northern Idaho.

Drilled-over plantings have been made in the outer drill width of a cultivated field adjacent to a fence row or a brush draw. In this type of location, safflower seems to contribute most to a winter habitat for pheasants.

Safflower prefers a clay loam or sandy loam soil of good depth. Best results, of course, have been obtained where soils have been well fertilized. Moisture is a critical requirement only during seed germination and until the seedling is well established. It stands drought well after flowering. Excessive moistures may be detrimental during the flowering period. Again in the fall after seeds have matured, excessive moisture may cause some seeds to sprout in the head. Even the sprouted seeds, however, are utilized by pheasants.

New varieties of safflower with significantly higher oil content are being developed by the University of Nebraska Chemurgy project. Cooperative plantings have been grown in California, Colorado, Idaho, Nebraska, Oregon, Utah and Washington. It is hoped that safflower may be tested quite widely for its value as winter food in the northern and western states.—K. E. HUNGERFORD, *University of Idaho, Moscow, Idaho.*

INCISOR WIDTH AS AN AGE CRITERION IN MUSKRATS

While the writers were engaged in graduate study at the Missouri Cooperative Wildlife Research Unit and later employed by the Missouri Conservation Commission, Federal Aid Program, data were gathered to test the usefulness of incisor width as a criterion of age in muskrats. This technique was suggested by Sooter (Jour. Wildl. Mgt., **10**(1):

68–70, 1946), who presented measurements of incisor widths of 245 individuals and pointed out that there was a "fairly definite segregation between adults and subadults." His table shows that there is some overlap. He determined the age by the method devised by Baumgartner and Bellrose (Jour. Wildl. Mgt., 7(1): 77–81, 1943).

In connection with studies of other age criteria in muskrats, incisor widths of 283 muskrats were measured by the investigators. These animals were taken in the Squaw Creek National Wildlife Refuge in northwestern Missouri and from the vicinity of Columbia in central Missouri in December, 1946 and December, 1947. Measurements were made at the gum line with a vernier caliper accurate to tenths of a millimeter. The following table shows the minimum, maximum and average incisor widths for each age and sex when the animals were grouped by the method suggested by Errington (Jour. Mammal., 20(4): 465–478, 1939).

The histogram presented below (Figure 1) illustrates the degree of overlap of incisor widths in age classes of Missouri muskrats. Two hundred and twenty-two of the 283 muskrats (78.4 per cent) are within the area of overlap when the widths are grouped in 0.2 mm. intervals. These muskrats were also grouped as to sex and age according to the criteria suggested by Baumgartner and Bellrose (op. cit.). When arranged in age groups by this method an even greater degree of overlap between the incisor widths of adult and immature animals was found. Moreover, fifty-four of these muskrats had been previ-

TABLE 1.—MUSKRAT INCISOR WIDTHS BY AGE AND SEX GROUPS

Age	Sex	No. Examined	Incisor Width in mm.	
			Average	Range
Adult	Male	53	8.1	7.0–9.7
Adult	Female	88	8.0	7.0–9.5
Subadult	Male	76	7.0	5.3–9.2
Subadult	Female	66	6.9	5.8–8.2

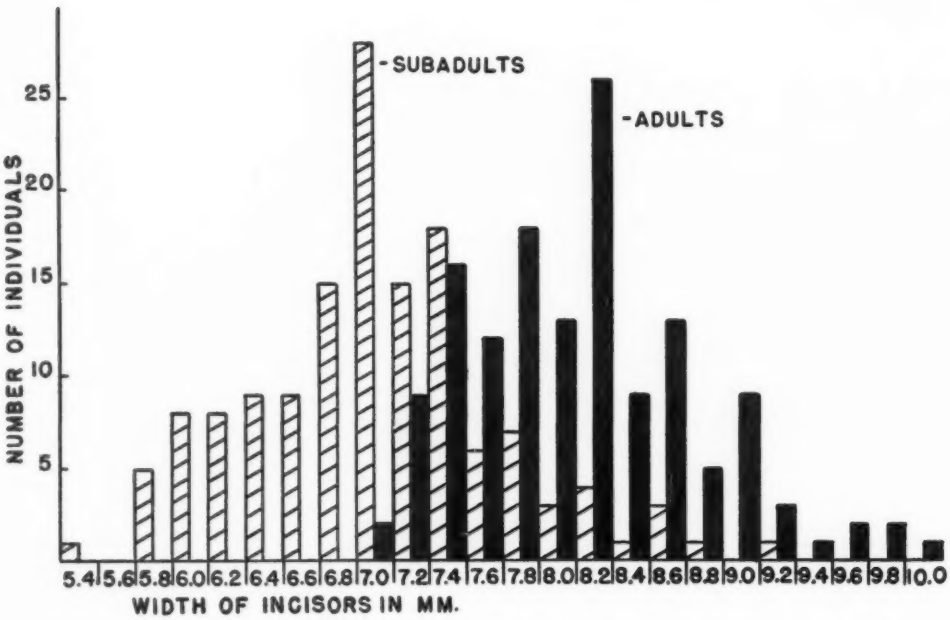

FIG. 1.—Distribution of incisor widths of 283 muskrats aged by examination of the reproductive system.

ously tagged, and were thus of known age. These tagged animals also were found to have a high degree (57.4 per cent) of overlap of the incisor widths of adult and sub-adult animals.

Although the upper incisors of adult muskrats average 1.09 millimeters wider than those of sub-adults, the range of incisor widths in the two age groups shows so high a degree of overlap that this method cannot be used to separate the age classes of Missouri muskrats.—ALLEN BROHN and CHARLES E. SHANKS, *Missouri Conservation Commission, Columbia, Missouri.*

REVIEW

The Pronghorn Antelope. By Arthur S. Einarsen. The Wildlife Management Institute, Washington, D. C. xvi+238 pp. Illustr. 1948. $4.00.

For those who have never been in antelope country but have a penchant for luxuriating through the winter evenings in an easy chair, for those who delight in recollections of antelope on some promontory, silhouetted against a blue sky which is synonymous with the West, for those who have seen the rich gold and white of antelope through the steel-blue sights of a high-powered rifle, and for those who are interested in prying into the intimate matters of daily and yearly life of this most unique of North American mammals, this book will be a desired possession. Mr. Einarsen has done us all a service in bringing together in a readable fashion a great deal of information on this species, much of it not previously generally available.

Following his introduction, the author has divided his material under the following headings: 1. History, Distribution, and Abundance; 2. Characteristics and Life History; 3. Pronghorn Antelope in Relation to Civilization; 4. Management of Antelope Resources; 5. How to Hunt Antelope; 6. Epilogue; and 7. Appendix.

Many of the book's inclusions will attract those interested in wildlife. For example, the life span in nature is quite short; the visual mechanism is so well developed that small moving objects can be detected at distances of from three to four miles; the unpredictable psychology of antelope is described; the factors making for good or poor range are outlined; reactions of populations to hunting pressure are discussed; and a comparative analysis of antelope and raw and evaporated cow's milk is given.

Through all that is excellent in this book, there are some things which do not measure up to the general standard. The author's occasional editorializing will meet with some resistance among wildlife workers, but as his own statements of opinion he is certainly within his rights to give them. There are several typographical errors so obvious that they should have been deleted early in the proof reading. There is little defense for spelling the generic name (*Astragalus*) for loco weed as *Astorlagus* on p. 62, and *Astralagus* twice on p. 69 and once on p. 70. Numerous such errors occur in the tables in the food habits section. Choice of words or phrases is sometimes not the best if not actually misleading, as on p. 86 where we find "... pronghorn deaths may often be classified as due to predation or disease, when actually they are due to natural causes." This reviewer wonders at this point what "natural causes" are. Again on p. 168 is the statement that "... accuracy (of shooting) was in direct relationship to distance," where "inverse relationship" is certainly the meaning intended. There are places, as in the last three sentences of the central paragraph on p. 159 where cause and effect are associated with too great facility on the basis of evidence given. As the great amount of the information was collected in and refers to Oregon, a subtitle indicating this geographical limitation would have been desirable.

These criticisms are made, not with the idea of detracting from the value of the book, rather to indicate a greater value had they been corrected.

Mr. Einarsen's thesis, as it unfolds through the pages, that values must be considered in antelope harvest other than the edible flesh furnished by a carcass, seems to be excellent. On p. 200 he states it as follows: "Gone forever are the often mentioned 'good old pioneering days!' It is a simple deduction that there is little comparison between the past and the present. In the past, a handful of hunters faced millions of pronghorns if early reports are correct. Now the existing pronghorns if exposed to unrestricted hunting would not survive one day's efforts by the well equipped and numerous license holders. It is time to substitute other values in hunting, emphasizing improvement in skill and wider appreciation of those attributes of aesthetic worth."

The illustrations are good and to the point. The makeup is excellent. We have again to thank the Wildlife Management Institute for this fine addition to our literature.—HARLOW B. MILLS.

Constitution and By-Laws of The Wildlife Society[1]

CONSTITUTION

ARTICLE I—Name

The name of this Society shall be The Wildlife Society.

ARTICLE II—Objectives

The principal objectives of the Society shall be: (1) Establishment of professional solidarity and the maintenance of the highest possible professional standards; (2) development of all types of wildlife management along sound biological lines; (3) publications to effect these ends; and (4) protection of the interests of its members.

ARTICLE III—Membership

Sec. 1. The membership of this Society shall consist of Active Members, Associate Members, Life Members, and Honorary Members.

Sec. 2. Active Members shall be persons professionally engaged in the practice or teaching of wildlife management, in wildlife administration, in wildlife research, or in graduate study of these subjects, who are graduates of a school approved by the Council, or who, in the opinion of the Council, have acquired an understanding of wildlife management principles and techniques comparable with that required by a school approved by the Council.

Sec. 3. Qualifications of applicants for active membership shall be passed upon by a standing committee of five members who shall be nominated by the Council and elected by the Society at its annual meeting; three members of the committee to be elected in odd numbered years, two members in even numbered years, to hold office for two years each. Election of applicants for active membership shall be made by the Council from among those recommended by the Membership Committee.

Sec. 4. Any person may become an Associate Member upon recommendation of two Active Members and acceptance by the Secretary.

Sec. 5. Honorary Members shall be persons who, upon a two-thirds vote of the Council and a two-thirds vote at any stated annual meeting of the Society, are thus recognized for their distinguished service or outstanding achievement in the field of wildlife management.

Sec. 6. Active Members shall be entitled to vote, to hold office, and to represent the Society officially. Life Members and Honorary Members who have been elected also as Active Members by the Council shall have such rights and privileges. All classes of members shall receive The Journal and such other publications of the Society as the Council may direct.

Sec. 7. Any Active or Associate Member may become a Life Member by paying the sum of $100.00 at one time into the Permanent Trust Fund. Life Members shall be exempt from payment of annual dues.

ARTICLE IV—Officers

Sec. 1. The officers of the Society shall be a President, a Vice-President, a Secretary, and a Treasurer.

Sec. 2. The officers shall be elected annually by mail ballot except as noted below. The President and Vice-President shall serve until May 1 of the calendar year following their election and shall not succeed themselves. The Secretary shall be elected in each odd-numbered year and shall serve until May 1 of the next odd-numbered year. The Treasurer shall be elected in each even-numbered year and shall serve until May 1 of the next even-numbered year. Within 60 days of assuming office the President shall appoint a Nominating Committee of five members. Before November 1 of that year the Nominating Committee shall submit to the Secretary two available Active Members as nominees for each office to be vacated. The Committee's nominations shall be published in the next January issue of The Journal of Wildlife

[1] Including revisions as of June 1, 1947. See previous constitution, Journ. Wildl. Mgt., 10: 361–364, 1946.

Management or Wildlife Newsletter. Within 30 days of the date of mailing of this issue the names of additional available nominees for any office to be vacated may be submitted by any voting member in good standing and any nomination will be valid if submitted by 5 per cent of the voting membership. The Secretary shall then mail an election ballot bearing the Committee's nominations and those made by the membership as herein provided. Thirty days shall be allowed for the election ballots to be returned to the Secretary. The nominee receiving the largest vote for each office shall be declared elected. In case of a tie, the decision shall be made by a majority of the Council. The out-going President shall appoint a three-member committee within thirty days after the election to audit the nomination and election ballots. The auditor's report on balloting shall be published in The Journal of Wildlife Management or Wildlife Newsletter.

Sec. 3. The President shall preside at meetings of the Society, shall be Chairman of the Council, shall appoint all Committees, except the Membership Committee, including those established by the Council, and perform other duties incident to his office.

Sec. 4. In the absence of the President or in his inability to act, his duties shall be assumed by the Vice-President. In the event neither one can serve, the Council shall appoint a President pro tempore.

Sec. 5. The Secretary shall be the Executive Officer of the Society under the general direction of the Council. He shall issue notices of annual or special meetings of the Society. A report covering his activities during the preceding year shall be made by him to the Society at its annual meeting.

Sec. 6. The Treasurer shall be responsible for all funds of the Society except permanent funds held in trust and shall be bonded in suitable amounts as decided by the Council and at the Society's expense. His accounts shall be audited at the close of each year as directed by the President before presentation at the annual meeting of the Society.

Sec. 7. Vacancies among the officers shall be filled by vote of the Council from among the Active Members for the unexpired term of the office.

Sec. 8. The Council, by a two-thirds vote, may combine the offices of Secretary and Treasurer into one office entitled the Executive Secretary. The Executive Secretary shall be appointed by a two-thirds vote of the Council. The Council may pay him a salary and expenses at its discretion and within sound financial limits of the Society. The Executive Secretary shall carry out the duties and make reports as specified in Sections five and six of this Article. The combining of the offices of Secretary and Treasurer shall take place on May 1, of some year, and a notice of such a union shall be made to the membership at least six months prior to the change. The Council, by a two-thirds vote, may eliminate the office of Executive Secretary, if conditions warrant, and restore the separate offices of Secretary and Treasurer, and have these offices filled according to Section two of this Article. A petition, having at least 10 per cent of the signatures of Active Members will be sufficient to require the Council to submit to the voting membership for approval or disapproval of the appointment or discharge of an Executive Secretary.

ARTICLE V—COUNCIL

Sec. 1. The Society shall be governed by a Council, composed of the President, Vice-President, Secretary, Treasurer, and at least one representative from each of the Regions as defined in the By-laws. The Regional Representatives shall be elected annually, shall be eligible for re-election and shall take office on May 1 following their election.

Sec. 2. The Council shall appoint the Editor; shall have power to fill vacancies occurring in its numbers; shall recommend to the Society for action By-laws not inconsistent with this Constitution and shall perform such other duties as are herein prescribed. Not less than one-half of the Members of the Council shall constitute a quorum.

Sec. 3. If the offices of Secretary and Treasurer are combined into an office of one person, entitled Executive Secretary, an appointee, the Executive Secretary shall not vote on Council affairs.

ARTICLE VI—MEETINGS

Sec. 1. The Society shall hold an annual meeting and such other meetings as the

Council may direct at places and dates selected by them. Due notice of such meetings shall be given by the Secretary at least thirty days in advance.

Sec. 2. Resolutions passed at a meeting of the Society by less than a majority of its Active Members shall represent the majority opinion of the meeting, but shall not be binding on the Society unless subsequently approved by the Council.

ARTICLE VII—SECTIONS

Sections of the Society may be authorized by the Council upon petition of ten or more Active Members. Sections may adopt necessary By-laws, providing that no part of them shall conflict with the Constitution of this Society. A report of its activities shall be presented by each section at the annual meeting of the Society.

ARTICLE VIII—DUES AND FUNDS

Sec. 1. The annual dues of Active Members shall be $5.00, and of Associate Members, $4.00. Subscriptions shall be $5.00 beginning with Volume twelve. No dues shall be charged Honorary Members.

Sec. 2. Annual dues shall be payable from January 1 in advance. Members in arrears shall forfeit their rights and privileges and shall receive no publications until such dues are paid.

Sec. 3. All monies accruing to the Society received for undesignated purposes shall constitute the Permanent Trust Fund, the proceeds from which shall be utilized to carry forward the work of the Society as directed by a three-fourths vote of the Council. In the absence of such direction, this income shall be reinvested by the Trustees.

Sec. 4. Bequests, grants or trusts made for the purpose of advancing the field of wildlife management and/or The Wildlife Society may be accepted by the Society, providing the Council shall have first favorably considered the objects and specifications set up by the trust. These shall be placed in the Permanent Fund.

Sec. 5. The Permanent Trust Fund of the Society shall be controlled in trust by a board of three Trustees with power to sell and reinvest according to their judgment. One Trustee shall be elected at each annual stated meeting for a term of three years. In case of vacancies caused by suspension, resignation or death, successors may be appointed by the Council for the remainder of the term. The Trustees shall be bonded in suitable amounts as directed by the Council and at the Society's expense.

ARTICLE IX—AMENDMENTS

The Constitution may be amended by a two-thirds vote of the Active Members of the Society, replying by ballot to a notice of the proposed amendment. Such notice must be submitted to all voting members at least thirty days previous to the closing date for the receipt of ballots. Amendments may be referred to the Society for action either by a two-thirds vote of the voting Members at any stated annual meeting, or by a favorable vote of at least two-thirds of the Council.

BY-LAWS

I. ELECTION OF OFFICERS

Election of officers shall be made by mail ballot as specified by the Constitution.

II. ELECTION OF COUNCIL

Representatives to the Council shall be chosen, one from each of the following Regions:

Region 1: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, Pennsylvania, New Jersey, Maryland, Delaware, District of Columbia, and West Virginia.

Region 2: Virginia, Kentucky, Tennessee, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Arkansas, Puerto Rico, and Virgin Islands.

Region 3: Ohio, Michigan, Wisconsin, Minnesota, Iowa, Missouri, Illinois, and Indiana.

Region 4: North Dakota, South Dakota, Montana, Wyoming, Nebraska, Colorado, and Kansas.

Region 5: Arizona, New Mexico, Texas, Oklahoma, and Mexico.

Region 6: Washington, Oregon, California. Idaho, Nevada, Utah, Alaska, and Hawaii,

Region 7: Canada.

Additional Regions may be established for similar representation upon approval by the Council. Representatives to the Council shall be elected in each Region by any plan acceptable to the Council.

III. ORDER OF BUSINESS

The order of business at the annual stated meeting, unless changed by a two-thirds vote of the Active Members present, shall be as follows:

1. Reading and approval of the minutes of the previous meeting.
2. Report of the Secretary.
3. Report of the Treasurer.
4. Report of Regional Representatives and Sections.
5. Appointment of temporary committees.
6. Report and recommendations by the Council.
7. Action on business reported by the Council.
8. Reports of committees.
9. New and unfinished business.

IV. DELINQUENTS

A member shall be dropped from the annual list of members after becoming one year in arrears of dues. A member shall be reinstated upon payment of dues for the current year in which application is made. Any member serving in the Armed Forces of World War II may obtain back numbers of The Journal of Wildlife Management for the time he was in arrears because of the war at regular subscription prices. All other delinquents shall pay current prices for back numbers.

V. FISCAL YEAR

The fiscal year of the Society shall end December 31.

VI. EDITOR

The Editor shall be appointed by the Council. He shall serve for one year, or until his successor is appointed, and shall be responsible for all matters relating to the publications of the Society, subject to such restrictions as may be imposed by the Council.

VII. BY-LAWS

By-laws may be adopted, amended or repealed at any annual meeting by a majority vote of the Active Members present.

INDEX FOR VOLUME 12

Aerial photographs
interpretation and suggested uses, 191
Dall sheep, 302
Allen, Durward L. Hunter management with multiflora rose, 325
Allen, George W. The management of Georgia deer, 428
Allen, Robert Ward (Obituary), 218
Anderson, Wallace L. Level ditching to improve muskrat marshes, 172
Aquatic plants
destruction of, 221
Ashbrook, Frank G. Nutrias grow in United States, 87
Atwood, Earl L. A nutritional knowledge short cut, 1

Baetjer, Edwin George (Obituary), 219
Barracuda
attack behavior, 117
Beaver
censusing, 214
Bennett, George W. Book review, 215
Borell, A. E. Five-year take record on a New Mexico duck marsh, 328
Bowers, Glenn L., see Tanner, Ward Dean, 112, 330
Brohn, Allen, and Charles E. Shanks. Incisor width as an age criterion in muskrats, 437
Buss, Irven O., see Kabat, Cyril, 399

Calhoun, John B. Utilization of artificial nesting substrate by doves and robins, 136
Calhoun, John B. Mortality and movement of brown rats in artifically supersaturated populations, 167
Cattle
on bear range, 57
coyote relationships, 73
Census
small mammals, 153
beaver, 214
Dall sheep, 302
Cooley, Marvin E. Improved toe-tag for marking fox squirrels, 213
Cooperrider, Charles Knesal (Obituary), 337
Cowan, I. McT. The occurrence of the granular tape-worm *Echinococcus Granulosus* in wild game in North America, 105
Coyote
control stations, 279
Curtis, James D. Animals that eat ponderosa pine seed, 327
Cypert, Eugene and Burton S. Webster. Yield and use by wildlife of acorns of water and willow oaks, 227

Dalke, Paul D. Some observations on den trees in the Missouri Ozarks, 107
Dambach, C. A. and D. L. Leedy. Ohio studies with repellent materials with notes on damage to corn by pheasants and other wildlife, 392
Davis, David E. and John T. Emlen, Jr. The placental scar as a measure of fertility in rats, 162
Deer
productivity and yield, 78
forage selection, 109
in Georgia, 428
Deer mice
live trapping, 211
Den trees
observations on, 107
Derby, J. V., see Nestler, R. F., 32
DeWitt, J. B., see Nestler, R. F., 32
Dieffenbach, Rudolph. River development programs and their relationship to fish and wildlife resources, 96
Dill, Herbert H. and Guy A. Greenwell. Improvements in efficiency in harvesting smartweed seed, 324
Doves
nesting, 136
Dozier, Herbert L., Merle H. Markley and Leonard M. Llewellyn. Muskrat investigations on the Blackwater National Wildlife Refuge, Maryland, 1941–1945, 177
Dozier, Herbert L. and Merton Radway. Pelting muskrats by air inflation, 333
Ducks
New Mexico marsh, 328

Emlen, John T., Jr., see Davis, David E., 162
Errington, Paul. In appreciation of Aldo Leopold, 341
Evans, Charles A. Obituary of Robert Gladding Green, 339

Fish
DDT or rotenone toxicity, 241
rotenone use in research, 305
adaptability of trout, 326

Fitch, Henry S. A study of coyote relationships on cattle range, 73
Frank, William John. Wood duck nesting box usage in Connecticut, 128

Gerking, Shelby D. Destruction of submerged aquatic plants by 2,4-D, 221
Gier, H. T. Rabies in the wild, 142
Glover, Fred A. Winter activities of wild turkey in West Virginia, 416
Gower, William Carl. (Obituary), 115
Graham, Samuel A. and Gene Hesterberg. The influence of climate on the ring-necked pheasant, 9
Green, Robert Gladding. (Obituary), 339
Greenwell, Guy A., see Dill, Herbert H., 324
Grenier, F., see Prévost, G., 241

Hamerstrom, F. N., Jr., see O'Roke, E. C., 78
Hardy, Thora M. Plitt. Wolverine fur frosting, 331
Hesterberg, Gene, see Graham, Samuel A., 9
Hill, Ralph R. and James W. Kimball. Uniformity of expression in game management, 232
Hinshaw, Maurice Layton. (Obituary), 220
Hoffmeister, Donald F., see Miller, Lowell S., 217
Hoffmeister, Donald F. Book review, 335
Hungerford, K. E. Safflower as a winter game bird food, 436

Jedlicka, John, see Thompson, David H., 433

Kabat, Cyril, Irven O. Buss and Roland K. Meyer. The use of ovulated follicles in determining eggs laid by the ring-necked pheasant, 399
Kimball, James W., see Hill, Ralph R., 232
Korschgen, Leroy J. Late-fall and early-winter food habits of bobwhite quail in Missouri, 46
Kozicky, Edward L. Some protozoan parasites of the eastern wild turkey in Pennsylvania, 263
Krumholz, Louis A. The use of rotenone in fisheries research, 305

Lanouette, C., see Prévost, G., 241
Leedy, D. L., see Dambach, C. A., 392
Leedy, Daniel L. Aerial photographs, their interpretation and suggested uses in wildlife management, 191
Leopold, Aldo. Obituary of Charles Knesal Cooperrider, 337
Leopold, Aldo
in appreciation of, 341
Llewellyn, Leonard M., see Dozier, Herbert L., 177
Loon
as a predator, 328

Markley, Merle H., see Dozier, Herbert L., 177
Mast
water and willow oaks, 227
McAtee, W. L. Obituary of Edwin George Baetjer, 219
McClure, H. Elliott. Factors in winter starvation of pheasants, 267
Meyer, Roland K., see Kabat, Cyril, 399
Miller, Lowell S. and Donald F. Hoffmeister. Book review, 217
Mills, Harlow B. Book review, 335 and 440
Mills, Harlow B. Note, 336
Moschler, M., see Nestler, R. F., 32
Multiflora rose
hunter management with, 325
Murie, Adolph. Cattle on grizzly bear range, 57
Murray, Robert W. Wintering bobwhite in Boone county, Missouri, 37
Muskrats
improving marshes for, 172
Blackwater National Wildlife refuge, 177
pelting by air inflation, 333
an age criterion, 437

Nestler, R. F., J. B. DeWitt, J. V. Derby, and M. Moschler. Calcium and phosphorus requirements of bobwhite quail chicks, 32
News notes, 113
Notes, 218, 336
Nutrias
in United States, 87
Nutrition
knowledge short cut, 1
Vitamin A storage, 332
Vitamin A and bobwhite quail, 251

Obituaries
Gower, William Carl, 115
Woods, Gordon Thomas, 115
Allen, Robert Ward, 218
Baetjer, Edwin George, 219
Hinshaw, Maurice Layton, 220

Cooperrider, Charles Knesal, 337
Green, Robert Gladding, 339
Leopold, Aldo, 341
O'Roke, E. C. and F. N. Hamerstrom, Jr. Productivity and yield of the George Reserve deer herd, 78

Partridge, Hungarian
nesting, 14
Petrides, George A. Book review, 215
Pheasants, ring-necked
climate influence, 9
nesting, 14
bag study, 20
winter starvation, 267
experimental feeding, 272
damage to corn, 392
determination of eggs laid, 399
Ponderosa pine seed
animals that eat, 327
Porcupine
checking crop depredations of, 110
Prévost, G., C. Lanouette, and F. Grenier. Effect of volume on the determination of DDT or rotenone toxicity of fish, 241
Provost, Maurice W. Marsh-blasting as a wildlife management technique, 350

Quail, bobwhite
nesting, 14
food requirements, 32
wintering, 37
food habits, 46
importance of vitamin A, 251

Rabies
in wildlife, 142
Raccoons
artificial dens, 296
Radway, Merton, see Dozier, Herbert L., 333
Rats
measure of fertility, 162
brown, 167
Reid, Vincent H. Lead shot in Minnesota waterfowl, 123
Reports, Wildlife Society
Business meeting of the Council, 318
Minutes of Annual Meeting, 319
Reviews, 112, 215, 335, 440
Rivers
development programs, 96
Robins
nesting, 136
Robinson, Weldon B. Thallium and Compound 1080 impregnated stations in coyote control, 279
Ruffed grouse
method for trapping, 330

Safflower
winter game bird food, 436
Sater, Edna N. Obituary of Maurice Layton Hinshaw, 220
Schultz, Vincent. Results of a vitamin A storage study, 332
Schultz, Vincent. Vitamin A as a survival factor of the bobwhite quail (*Colinus v. virginianus*) in Ohio during the winter of 1946–47, 251
Scott, Walter E. Methods of controlled public hunting in the United States and Canada, 236
Shanks, Charles E., see Brohn, Allen, 437
Sharks
attack behavior, 117
Sheep, Dall
air census, 302
Shoemaker, Hurst H. Book review, 112
Siegler, Hilbert R. Adaptability of brook trout, 326
Siegler, Hilbert R. One loon a villain, 328
Smartweed
harvesting, 324
Special techniques
marsh-blasting, 350
dyeing birds, 388
Spencer, Donald A. An electric fence for use in checking porcupine and other mammalian crop depredations, 110
Squirrels, fox
technique, 213
Stewart, Robert E., see Stickel, William H., 218
Stickel, Lucille F. The trap line as a measure of small mammal populations, 153
Stickel, Lucille F. Effect of bait in live trapping *Peromyscus*, 211
Stickel, William H. and Robert E. Stewart. Obituary of Robert Ward Allen, 218
Stuewer, Frederick W. Artificial dens for raccoons, 296
Sumner, Lowell. An air census of Dall sheep in Mount McKinley National Park, 302
Swank, Wendell G. Beaver censusing by airplane, 214
Swift, R. W. Deer select most nutritious forages, 109

Taber, Richard D., see Thompson, Donald R., 14
Tanner, Ward Dean and Glenn L. Bowers. Book review, 112
Tanner, Ward D. and Glenn L. Bowers. A method for trapping male ruffed grouse, 330
Tape-worm
in wild game, 105
Thompson, David H. and John Jedlicka. A method for correcting kill estimates from waterfowl banded during the hunting season, 433
Thompson, Donald R. and Richard D. Taber. Reference tables for dating events in nesting of ring-necked pheasant, bobwhite quail, and Hungarian partridge by aging of broods, 14
Trippensee, R. E. Obituary of Gordon Thomas Woods, 115
Turkey, wild
protozoan parasites, 263
winter in West Virginia, 416

Uhlig, Hans G. Experimental feeding of ring-necked pheasants in the Willamette Valley, Oregon, 272

Wadkins, L. A. Dyeing birds for identification, 388
Waterfowl
lead shot study, 123
method for correcting kill estimates, 433
Webster, Burton S., see Cypert, Eugene, 227
Whitlock, S. C. Obituary of William Carl Gower, 115
Wolverine
fur frosting, 331
Wood duck
nesting box usage, 128
Woods, Gordon Thomas. (Obituary), 115
Wright, Bruce S. Releasers of attack behavior pattern in shark and barracuda, 117